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# Un-Splintering Urbanism: Examining the Integration of Urban Infrastructures

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# ABSTRACT

Modern cities today are dependent upon the large infrastructure networks that provide citizens with food, energy, water, telecommunications, transport and waste removal, yet in many cities infrastructures are more than a century old and in need of replacement or repair. The privatisation of many utilities and the often 'siloed' management structures of infrastructures can create problems arising from the lack of 'integrated' service provision. Today there is a growing discourse around the potential for 'infrastructure integration' which is offered as a way to create resource and service efficiencies and to create space for technical and system innovations. There is recognition that future infrastructure needs to be smarter, more cost-efficient and more environmentally friendly and 'integration' is often cited as a way to achieve this.

However, what exactly is meant by the term infrastructure integration? Although there is broad agreement about the importance of integration, precisely what this means in practice is unclear. This PhD project aims to open the black box of infrastructure integration, to examine the evolving context and the potential of integration and to explore its meanings and implications in theory and practice. The conceptual ideas of the study are grounded on in-depth qualitative research in three cities reflecting different institutional and cultural contexts: Seattle in the United States, Munich in Germany, and Sheffield in the United Kingdom. The approach seeks to test some hypotheses about the links between the institutional, organisational and regulatory context of cities and the potential for urban infrastructure integration.

I treat infrastructures as socio-technical systems and I aim to demonstrate that the meanings and implications of infrastructure integration are dependent upon the socio-political institutional frameworks that cities operate in. This research finds three different forms of infrastructure integration: evolutionary integration in Seattle, in which integration arises out of the day to day operational necessities of infrastructure management; innovative integration in Munich, in which integration arises as a result of innovative organisational practices inherent within the city; and aspiring strategic integration in Sheffield, in which the city aims to coordinate the investment priorities of privatised utilities, yet lacks the authority to coerce the privatised utilities to cooperate.

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# CONTENTS

## List of Figures



## List of Tables

# 1 INTRODUCTION

The aim of this thesis is to examine the evolving context and the potential for infrastructure integration within cities. Modern cities are reliant upon the often hidden networks of energy, water, waste, transport and telecommunications that have become ubiquitous in the developed world. The privatisation of many utilities and the often 'siloed' management structures of infrastructures can create problems arising from the lack of 'integrated' service provision and management. There is an argument that future infrastructure needs to be smarter, more cost-efficient and more environmentally friendly and the integration of infrastructures is often cited as a way to achieve this (Roelich et al. 2015, ARUP 2013). Yet it can be difficult to identify just what infrastructure integration can mean and how it can be operationalised within an urban concept. It is also debatable as to whether integration is possible or desirable, and if it does occur at what spatial scale should it be pursued? Although there is broad agreement about the importance (and the potential) of infrastructure integration, precisely what integration means in practice is unclear. It could be argued that the term itself is an abstract aspiration or a nebulous guiding principle with no concrete definition. The concept raises a lot of questions for practice and for future research.

This thesis aims to examine the evolving context and the potential of infrastructure integration, exploring its meanings and implications in theory and practice. The overall aim is to open the 'black box' of infrastructure integration, to examine the potential for integration to occur in three case study cities, and to identify what forms (if any) of infrastructure integration are taking place. This thesis examines infrastructure integration within an urban context. Cities and infrastructures have coevolved together and infrastructural flows have become indispensable to the functioning of urban space and economic activity (Williams, Bouzarovski and Swyngedouw 2014). Despite this, the urban dimension of infrastructural restructuring has been underexposed by academic researchers (Monstadt 2009) and there is little research on what the integration of urban infrastructures may entail. The conceptual ideas of the study are grounded on in-depth empirical research in three cities which reflect different institutional and cultural contexts for thinking about urban infrastructure integration. The approach seeks to test some hypotheses about the links between the institutional, organisational and regulatory context of cities and the potential for urban infrastructure integration. The three cities studied in this project are Seattle in the United States, Munich in Germany, and Sheffield in the United Kingdom.

The remainder of this introductory chapter sets out the key elements of the thesis. First, it begins with an examination of the growing discourse surrounding infrastructure integration. Then, it seeks to outline the importance of the urban to infrastructural discussions. Next, I outline the overall aims and objectives of the study before discussing the philosophical foundations of the research. The chapter ends with an outline of the structure of the PhD.

## 1.1 The Discourse of Infrastructure Integration

Current research on the potential for environmentally sustainable cities emphasises the benefits of infrastructure integration to maximise returns on investment, minimise the costs of technological replacement and renewal, and to deliver a more citizen-focused approach to service provision (UNEP 2012). Pressures arising from the need to tackle climate change, reduce resource usage, and accommodate new technological innovations are leading to calls for changes in the provision and management of urban infrastructure (Wilbanks and Fernandez 2014). There is growing interest in the potential for resource and service efficiencies, as well as technical and system innovations, through various types of infrastructure integration (EEA 2015b, UNEP 2012). To some degree it could be argued that infrastructure systems have always been dependent upon one another and varying degrees of interdependencies exist at many scales: energy generators need constant supplies of water to operate; electric trains need an uninterrupted supply of power; and urban waste removal services are reliant upon transportation networks. Despite these interdependencies, however, infrastructure networks are often splintered and managed independently in discreet silos (Graham and Marvin 2001), arguably due to the impacts of privatisation and the unbundling of infrastructures. Much decision making and policy evaluation remains in "separate and disconnected institutional entities" (Rogner 2009: 4) and the results of such 'siloed' thinking could be "suboptimal resource allocations, counter-productive policies and, at worst, [the acceleration of] long term unsustainable development" (IAEA 2009: 11). While officials know how to organize and regulate individual networks, a modern challenge is to understand, coordinate and manage multiple systems as a holistic whole (Lorrain 2001).

The discourse of infrastructure integration has ebbed and flowed over the last century, usually becoming more prevalent when existing norms are challenged by a threat of crisis (e.g. increased costs, new regulatory challenges, or external shocks such as the 1970s oil crisis). The issue appears to have grown in importance in recent years, not only due to concerns over climate change, population growth, neoliberal economic policies and resource sustainability, but also as a result of debates over new technological possibilities and modern discourses surrounding 'smart' cities. The benefits of integration are often cited: for example Moss, Naumann and Krause (2017) argue that concerns over water shortages due to climate change are leading to compelling arguments for a stronger coupling of the water and energy sectors, which could "present resource synergies with reciprocal effects ranging from the global to the local scale" (Moss, Naumann and Krause 2017: 280). Williams et al (2014) argue that the concept of integration has become a 'panacea' amongst policy making circles and that, fundamentally, "the call for integration through policy change and technological development is a call for the eradication of inefficiencies" (Williams et al. 2014: 13).

Interest in the concept of infrastructure integration has grown since the turn of the 21st Century. A search for the term 'integrated infrastructure' on the online platform Science Direct returns a total of 1,386 published academic papers that contain the phrase (as of March 2018) with around two thirds published since 2008 (958 papers). This PhD project is funded by the United Kingdom's Engineering and Physical Sciences Research Council (EPSRC) which has called for "new ways of thinking around integration of utilities [which] may offer major breakthroughs and could identify opportunities for co-location and co-ordination of investment in large infrastructure assets" (EPSRC

2010). The European Innovation Partnership on Smart Cities and Communities (EIP-SCC) cites integration as a key policy goal:

> "Significant and as yet insufficiently tapped value is offered by integrating the various existing and new infrastructure networks within and across cities – be they energy, transport, communications or others – rather than duplicating these needlessly. This point applies, both, to active and passive infrastructure. Many such infrastructures are ageing; budgets to replace them are stretched; they are procured and managed 'in silos'; yet the potential afforded to cities and their customers through new joined-up approaches, exploiting modern technologies is substantial" (EIP-SCC Undated: para 1).

In practice, however, the integration of various infrastructural services may be more difficult and complicated than the literature might suggest. Existing governance arrangements are not easily unbundled. It requires intervention and political will from actors with the authority to affect change. In practice, infrastructure integration may create only limited gains in terms of efficiency or sustainability, and integration could be a complex process occurring at multiple scales. Would it be beneficial to have decisions made by a single state-owned integrated organisation? Many infrastructural networks have been historically managed as separate and isolated sectors: they have their own ownership structures, accountancy rules and regulatory frameworks, and there has been little desire to create more integrated systems at a national regulatory level. Many countries manage their networks with "deeply engrained ways of sector-biased thinking" (Moss et al. 2017: 281). It may be the state lacks the flexibility and capacity to be able to adapt quickly to external resource threats or to mobilise taxpayer support to fund expensive infrastructural renewal projects. Conversely many private utilities are run by actors sensitive to commercial interests and can often seek short-term benefits at the expense of complex yet potentially more beneficial long-term solutions. Even in a deregulated and privatised environment utilities are often constrained by a complex regulatory regime that imposes price-controls and constraints over network autonomy. Attempts to integrate infrastructures within this context could be problematic.

Several academic researchers have begun to explore the concept of infrastructure integration. Moss et al (2009), in examining Integrated Water Resources Management policies, use the concept of integration to cover the enrolment of "key representatives of the relevant agencies and actor groups and keeping the general public informed", alongside regional integration within the water sector (Moss et al. 2009: 20). Rogers et al (2012) outline the symbiotic relationship between the various buried and surface networks, calling for the integration of information between organisations to allow engineers to fully assess the condition of pipes and cables before any remedial work is undertaken. Yet these definitions of what integration may actually entail are too narrow for the purposes of this thesis, and they only begin to explore the issues involved. There has been little analysis and understanding within the academic literature of what the definition of 'infrastructure integration' can be. While there is widespread recognition that integrated thinking could be beneficial, questions surrounding what to integrate, how, and at what scale, are often left unanswered. The concept of infrastructure integration is "unquestioned and never problematized, but one that is consistently ill-defined" (Williams et al. 2014). The term has become something of a buzzword that very few people can disagree with, but it has to be situated in particular organisational, resource, and knowledge contexts. The concept appears to be fluid, flexible, and fuzzy, with different meanings depending on the context. As Sayer (1992) has suggested, making a

flexible concept the object of academic study may throw light on the political interests and motivations of those who use the term. Is the flexibility inherent within the term 'infrastructure integration' one of its strengths? Or does it conceal the true motivations and power relations deployed in its usage? Has the term become a meaningless chaotic conception of little or no analytical value? Or is it a rational abstraction that is useful for analysis (Sayer 1992: 138)? Chaotic conceptions can be used in everyday life or scientific practice for descriptive purposes but can become problematic when any explanatory weight is placed upon them (Jackson, Ward and Russell 2006). Exploring the concept of infrastructure integration is a useful study in its own right. By examining the meanings of integration in three case study cities it may be possible to make sense of the current 'fuzziness' surrounding the term.

## 1.2 The Importance of Urban Infrastructure Integration

This thesis seeks to examine the integration of infrastructures within an *urban* context, for three main reasons. First, the urban arena has become a vital site for infrastructural interventions and networks can act as an investment spur that can drive the economic and environmental vitality of urban areas (Arts et al. 2016). The growth and vibrancy of modern cities arguably depends on the development of new technological and infrastructural innovations (Gann, Dodgson and Bhardwaj 2011). As such, infrastructural management is becoming an increasingly important concern for urban politics. It is likely that the majority of socio-technical innovations to modernise infrastructures, experiments to improve ecological sustainability, and changes in management, organisational and institutional structures are geographically concentrated within urban areas (Monstadt 2009). In many cities in the western world the major infrastructures are in some cases more than a century old and in need of replacement or repair (Houlihan 1994). In London, for example, a large part of the system of sewers and water pipes that form the backbone of the city was developed in Victorian times. These decaying pipes are in urgent need of replacement and contribute to the loss of 26 per cent of all the water that passes through them due to leakage – equating to 200 litres per customer per day (Pearce 2012). Calls to move towards integrated infrastructural operations within cities may be a response to the growing cost of repairing and upgrading existing networks.

Second, despite the important links between cities and infrastructures they have been largely ignored as a coevolving socio-technical system within academic and political arenas (Monstadt 2009, Coutard 1999). In the United States for example, a national assessment on the impacts of climate change did not begin to examine cross-sectoral issues related to infrastructures and urban systems until 2014 (Wilbanks and Fernandez 2014). This lack of attention is reflected in much of the academic literature. Coutard (1999) argues that there is a need for research to firmly establish the link between infrastructures and the urban. Cities are huge consumers of resources and reliant on the infrastructural networks that offer quality of life to citizens. As such, the "relations between urban governance and infrastructural systems now deserve to be systematically investigated, in their economic, social, environmental and political dimensions" (Coutard 1999: 12).

Third, the social, economic, political, institutional and regulatory variations between cities offers a rich vein of research for any multi-case study project. Cities differ in their capacities and capabilities

for developing strategic responses to the opportunities and constraints posed by infrastructural concerns (Hodson and Marvin 2009). The governance of infrastructures can differ not just between cities but also within cities. The early electrification of London acts as an example. By 1918, the high demand for electrical power and the desire for companies to tap into the lucrative market led to 70 governing authorities, 50 different types of systems, 10 different frequencies and 24 varying voltages attempting to supply the city (Powells, Bulkeley and McLean 2015). The three cities chosen for this research differ in their histories, their levels of infrastructural provision and in their institutional and regulatory relationships with other cities and national governments. The intersection of urban politics and infrastructure integration raises questions about sub-national jurisdictional power and the three cities differ in the level of authority they have over infrastructural concerns, the ability for urban actors to intervene within networks, and the form and scale of any integration which may occur.

## 1.3 Aims and Objectives

This PhD project is funded by the United Kingdom's Engineering and Physical Sciences Research Council (EPSRC) and is jointly supervised by Sheffield University academics Dr Aidan While (from the Department of Urban Studies and Planning) and Prof Martin Mayfield (from the Department of Civil Engineering). The overall aim of the thesis is to examine the context and meanings of urban infrastructure integration. Under this aim there are four primary objectives.

1) To develop a conceptual framework for researching urban infrastructure integration.
2) To examine perceptions of the rationale, opportunities and potential constraints for enhanced urban infrastructure integration in the three case study cities.
3) To investigate examples of effective urban infrastructure integration in the three case study cities, to understand what can facilitate integration and what can constrain it.
4) To contribute to wider conceptual discussions about the ideas and definitions of infrastructure integration.

As mentioned above, this research is a multi-case study project investigating three cities: Seattle, Munich and Sheffield.

Seattle represents a city with a potentially conducive context for innovation in infrastructural networks. The federalised decision-making structure within the US allows cities to maintain a degree of autonomy over infrastructural management, and a professionalised civil service can allow for long-term decisions to be taken by knowledgeable technicians (Clingermayer and Feiock 2001). Seattle receives around 90 per cent of its power from hydro-electric power plants fed by nearby mountain glaciers (Fullerton Jr, Juarez and Walke 2012). It has a city-owned energy and water utility enthused with what appears to be a strong public ethos and a commitment to provide affordable and high-quality services to its citizens (Rice 2010). Arguably, if the integration of infrastructures is occurring anywhere, it should be occurring within Seattle.

Munich represents a city with a reputation for strong institutional frameworks for urban governance and as a city that is actively pursuing and supporting various forms of infrastructure integration projects. As in many German cities Munich's infrastructures are governed through the *Stadtwerke* ('City Works') – a city-owned enterprise that provides electricity, gas, water, transport and telecommunications. The S*tadtwerke* would appear to provide an appropriate location for forms of infrastructure integration to occur and there appears to be strong networks between public and private actors involved in urban governance that could facilitate various forms of integration.

Sheffield represents a city in which infrastructure integration may be difficult. Cities within the UK have little authority to intervene in the privatised infrastructural markets and the major utilities are splintered and siloed from each other (Graham and Marvin 2001), restricting the activities of city officials who may wish to pursue policies of integration. Sheffield offers an opportunity to investigate the potential for infrastructure integration within a city which may find it difficult to intervene in infrastructural concerns.

## 1.4 Philosophical Framework: A Critical Realist Approach

The foundation of any academic study rests on certain philosophical assumptions that can inform understandings and guide research, and before outlining the structure of this PhD it is important to discuss the ontological and epistemological positions that underpin this project.

A key question for researchers within the social sciences is whether the social world can and should be studied to the same ethos, procedures and principles as subjects within the natural sciences (Bryman 2012). Those who argue the scientific method should be similar tend to argue from a positivist standpoint, which is usually associated with the natural sciences but can be found within social studies concerned with rational, logical and intentional forms of social improvement and social engineering (Kilborne 1992). There are a number of features associated with positivist research: that knowledge can be gained through the objective (that is, value free) gathering of facts that provide the basis for laws and regulations; that academic theories should be used to generate testable hypotheses; that the explanations for the impacts of laws should be assessable (deductivism); and only phenomena (and therefore knowledge) confirmed as actually existing can be genuinely warranted as scientific knowledge (Bryman 2012: 24). Proponents of positivism maintain that it is only by applying the methods of the natural sciences that social science will ever be able to match the results in explanation, prediction and control (Lee 1991) and positivist studies can be found throughout social research. A number of studies within the field of marketing, for example, appear to take a positivist stance to research in arguing that by simply increasing the number of cases subject to study, it may be possible to create a quantifiable dataset and develop a set of social laws that are akin to those developed by the natural sciences (Easton 2010, Sayer 2000). One main problem with positivism is the belief that concepts, entities and processes must be observable because, "if the concept cannot be observed and measured, it does not exist" (Devers 1999: 1158). The argument throughout this thesis is that the concept of urban infrastructure integration is nebulous and contested – is it possible to quantify the meanings and nuances of an ill-defined concept using purely positivist research methodologies? Purely positivist research can also prove

problematic within the hard sciences – scientific explanations of environmental degradation, for example, may provide only partial insights into the complexity of biophysical processes by uncritically reflecting the agendas of the organisations or societies that created them, or by ignoring the impact on certain social groups altogether (Forsyth 2001).

A second philosophical perspective used within the social sciences is interpretivism. Interpretivism contrasts with positivism, with interpretivist researchers arguing the subject matter of the social sciences – such as institutions, organisational structures and people – is fundamentally different from that of the natural sciences (Bryman 2012: 26). As a result, science should acknowledge that there is a difference between humans and the natural order and that human behaviour is a result of how people interpret the world (Bryman 2012: 27). Instead of relying on the observation and measurement of quantifiable entities or processes, social scientists should instead interpret people's actions and their social world from their own point of view. Common methods used within the interpretivist approach are ethnography, hermeneutics and phenomenology (Lee 1991) and the approach emphasises detailed case study research, authentic data capture and sensitive data analysis (Easton 2010). While the interpretivist school is useful in examining complex and detailed social situations, human processes and institutional structures, interpretivists "deny the possibility of knowing what is real and reject the possibility of discerning causality", instead believing researchers can only apply their own interpretations to events and situations. (Easton 2010: 118).

To address the problems associated with both these philosophical positions the ontological and epistemological perspective of this thesis is based on critical realism, developed by Roy Bhaskar and advanced by Andrew Sayer (Bhaskar 1978, Sayer 2000, Sayer 1992). Critical realism is often seen as a way to navigate between the positivist empiricism implicit within the physical sciences and the interpretative methodologies often adopted within the social sciences (Gerrits and Verweij 2013). The theory originated as a scientific alternative to both positivist and interpretivist forms of research, yet draws elements from both strands in its account of ontology and epistemology (Fletcher 2017).

Critical realists argue that reality can exist relatively or absolutely independently of human thought, that knowledge is always fallible (however not all knowledge is equally fallible) and our knowledge of reality is socially produced (Bergene 2007). According to critical realists the world is "composed not only of events, states of affairs, experiences, impressions, and discourses, but also of underlying structures, powers, and tendencies that exist, whether or not detected or known through experience and/or discourse" (Patomaki and Wight 2000: 223).

Critical realists argue that reality is 'layered' into three different levels of reality: the empirical, the actual and the real. The *empirical* level is the realm of events and objects as humans experience them (Fletcher 2017). Empirical observations can uncover these events or objects, however these events are also "mediated through the filter of human experience and interpretation (Fletcher 2017: 183). Social ideas, actions, meanings and knowledge all occur within this level of reality, and importantly these features can be causal. The middle level of reality is the *actual,* which contains the events or objects that can be identified (yet remain distinct) from empirical impressions. These events or objects can exist independently of human thought and do not need human interactions to exist. They can occur whether or not humans experience or interpret them. The third level of reality refers to the *real*, or structured objects or forces which can create tendencies in the course of actual

events. This level of reality is where 'generative mechanisms' exist, which are "inherent properties in an object or structure that act as causal forces to produce events" (Fletcher 2017: 183).

Fletcher (2017) argues that critical realism can be seen as a three-layered 'iceberg' of reality (Figure 1.1) and it is the "primary goal of CR to explain social events through reference to these causal mechanisms and the effects they can have"(Fletcher 2017: 183). All levels are part of the same reality. Objects can exist independently of our knowledge of them, and can be structured to such an extent that they cannot be reduced to the actual events of the empirical impressions they produce. Okoli argues the basic formula for critical realism is "*real mechanisms* have the potential to sometimes cause *actual events* in the world, which might or might not be *empirically observable*" (Okoli 2015: 7). Fletcher adds:

> "As Bhaskar (1979) pointed out, unlike the natural world, social structures are in fact activity-dependent. In other words, causal mechanisms 'exist only in virtue of the activities they govern and cannot be empirically identified independently of them' (p. 48). This means that causal mechanisms are social products that can ultimately be understood through – and indeed, that *exist within* – phenomena at the empirical level (e.g. human actions and ideas that are generated by these mechanisms), making these phenomena relevant for scientific investigation" (Fletcher 2017: 183).

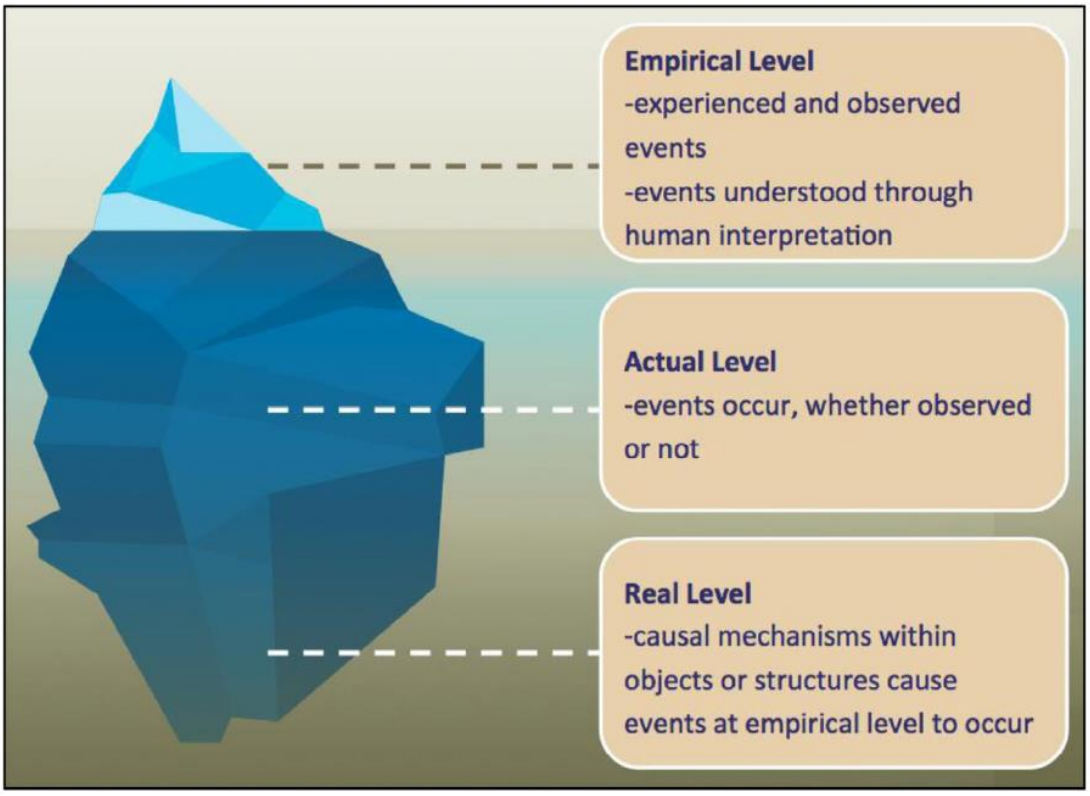


**FIGURE 1-1 AN ICEBERG METAPHOR FOR CR ONTOLOGY (FLETCHER 2017: 183)**

The mode of inference implied by critical realism is neither deductive nor inductive, but rather a form of *retroduction,* consisting "in the movement, on the basis of analogy and metaphor amongst other things, from a conception of some phenomenon of interest to the development of a model of some totally different type of thing, structure, or condition that, at least in part, is responsible for

the given phenomenon" (Patomaki and Wight 2000: 224). What is important is to identify the structures, powers and tendencies that contribute to particular phenomenon (what Bhaskar describes as 'generative mechanisms' (Bhaskar 1978: 50)) and to explain and analyse what that contribution entails. Researchers are able to examine the entities and processes that constitute the phenomenon of interest (in this case the concept of urban infrastructure integration) and while these entities and processes may not be directly observable, their effects are and can therefore be advanced as suitable theoretical accounts (Bryman 2012).

Proponents of critical realism argue that there is a real social world we can research and attempt to understand, however some knowledge on how to describe and understand that world can be closer to reality than others (Fletcher 2017). As Fletcher (2017) argues, "the theories that help us get closer to reality, i.e. that help us identify causal mechanisms driving social events, activities, or phenomena, are selected and formed using rational judgment of these social events" (Fletcher 2017: 182). Critical realism can thus help a researcher engage in explanation of what is causing (or at least contributing to) various social actions. Critical realism's "fundamental claim of the commensurability of different philosophical paradigms and modes of inquiry makes it very appropriate to guide the synthesis of diverse kinds of research study" (Okoli 2015: 2).

One aspect of critical realism that is important to this PhD is an acceptance that the world is "characterized by emergence, that is situations in which the conjunction of two or more features or aspects gives rise to new phenomena" (Sayer 2000: 12). The complexity inherent within society creates messy, contested and difficult to research phenomena that do not easily lend themselves to positivist research methodologies. Indeed, positivism "systematically misrepresents society by presenting such phenomena as reducible to independent individuals or atoms" (Sayer 2000: 13). The emergence of differentiated behavioural patterns associated with new technological innovations are often context specific and difficult to foresee. Similar computer systems introduced into two different organisations, for example, may produce different results depending on the institutional structure, the expertise of those interacting and interpreting the new system, and the differing historical processes at work (Barley 1986). As such, the meaning of objects, actions and citizens "has to be understood, it cannot be measured or counted and hence there is always an interpretive or hermeneutic element in social science" (Sayer 2000: 17).

In describing a critical realist political ecology, Forsyth cites the need to "understand the political ramifications" of certain issues, but "in a way that acknowledges the social and political construction" of definitions (Forsyth 2001: 3). The contribution of this PhD will be to advance definitions of infrastructure integration, as well as the social and political constructions of such definitions. I treat infrastructures as complex socio-technical systems, in that they are both socially constructed and society shaping (Hughes 1987). Critical realism appears to be a natural bedfellow in research studies using this definition of socio-technical systems: it can help researchers to explain social events and suggest practical policy recommendations to address social issues (Fletcher 2017).

## 1.5 STRUCTURE OF THE PHD

This thesis is structured as follows:

**Chapter 2: The Idea of Urban Infrastructure Integration: Building a Conceptual Framework.** After this introductory chapter, the research begins with a review of the academic literature and the creation of a conceptual framework that can underpin the remainder of the thesis. First, I classify infrastructures as socio-technical systems that are embedded within wider institutional contexts, arguing it is at the urban scale that infrastructure interventions may have the most impact. Second, I explore the literature on 'infrastructure integration' before creating a working definition of the concept that can underpin the remainder of this thesis: that it is almost universally viewed as beneficial, that it can occur at multiple scales and take multiple forms. Finally, I seek to create a conceptual framework in which we can situate the forms of integration that emerge in the empirical research.

**Chapter 3: Methodology.** Chapter 3 provides the methodology for this research project. Drawing on the literature reviewed in Chapter 2, and taking into account the aspects of infrastructures and integration that are important, I seek to create a set of research questions that are to be answered by this project. The research utilises a comparative case study method using qualitative research underpinned by critical realism. Chapter 3 contains an explanation of the choice of case study cities, an outline on how the interviews were managed (and with who) and how the data was analysed.

**Chapter 4: Varieties of Infrastructural Management.** Chapter 4 contains an exploration of the differences between the US, the UK and Germany in terms of how their network infrastructures are governed, how the concept of the state can impact upon network infrastructures, and the varying levels of authority and independence offered to cities. It is my argument that the US features a weak federal government forced to adopt carrot and stick approaches of finance and regulations to promote its policies to the state and city levels of government. The UK, in contrast, has a strong central government able to promote more market-friendly and profit-driven policies, often against the will of the local levels of state. Germany acts instead as a networking state, utilising partnership working across all vertical areas of governance (federal, state, local) and horizontal levels between business, unions and third parties. The variations between these three countries can lead to variations in infrastructural management.

**Chapter 5: Seattle: The Evolutionary City.** Chapter 5 marks the beginning of the empirical section of this thesis. While Seattle appears to be a city with a potentially conducive context for innovation in urban integration (with a mix of high-tech multi-national corporations, large renewable resources and publicly-owned utilities) the research process revealed a number of regulatory, cultural and political hurdles that can act against it. I argue that infrastructure integration within Seattle appears to take an *evolutionary* form, being opportunity-driven, occurring only when necessary and revealed through the day-to-day operational tasks of utility employees.

**Chapter 6: Munich: The Innovative City.** In contrast to Seattle, Munich appears to be a city with an overt aim of increasing forms of infrastructure integration, which occurs as a result of the *innovative urban processes* that are inherent to the institutional structure of the city: a large mix of

technological innovative companies; context-specific governance arrangements that allow for city independence and operational autonomy; locally-tailored technological solutions for individual projects; and flexible organisational arrangements able to adapt to complex and rapid changes in national and international regulatory regimes.

**Chapter 7: Sheffield: The Aspiring Strategic City**. Sheffield acts as an example of a city in which direct infrastructural interventions may be difficult, yet the city does demonstrate what I argue are *aspiring strategic* forms of integration, in that the city's local authority seeks to intervene indirectly through the creation of urban masterplans and new organisational structures that can act to control and coerce the privatised utilities to act in specific ways. However, the lack of authority the city has to coerce the privatised and national utilities to cooperate means the idea of acting in a strategic manner means it remains an aspiration rather than reality.

**Chapter 8: Conclusion.** In the concluding chapter I sum up the primary arguments made in this thesis, attempt to answer the research questions, list the contributions of this project, and identify future areas for possible research.

# 2 THE IDEA OF URBAN INFRASTRUCTURE INTEGRATION: BUILDING A CONCEPTUAL FRAMEWORK

As outlined in Chapter 1, recent years have seen a growing debate around the idea of infrastructure integration, yet while the term has found its way into discourses around network and urban planning, there has been little analysis within the social sciences of what it might mean in practice beyond the normative ideal. This can create problems when operationalising the term as a research activity or as a framework for intervention. Any qualitative research underpinned by critical realism has to begin by identifying the entities, behaviours or objects that characterise the phenomena being studied (Easton 2010). This chapter reviews the debate and highlights the opportunities and challenges in thinking about infrastructure integration.

The chapter starts with an exploration of the features that are important to infrastructure research. In Section 2.1 I argue there are three issues that need to be taken into consideration when analysing infrastructures. First, that infrastructures are socio-technical systems that are both socially constructed and society shaping. Second, these socio-technical systems are embedded within wider institutional structures which can frame and shape their creation and development. Third, there are particular issues about the notion of urban infrastructure integration, as opposed to integration at the national or international scale. Following this initial scene-setting, in Section 2.2 I conduct a literature review on the concept of 'infrastructure integration', beginning with an exploration of the 'splintering urbanism' theory that can help situate the contemporary calls being made for integration. I then examine a number of academic studies that are important to infrastructure integration, such as the literature covering the 'nexus' of energy, water, and food, various 'smart' city debates, and the system of systems approach to infrastructural management. In Section 2.3 I discuss the commonalities that arise from the literature review that can be used to create a working conceptualisation of infrastructure integration. I conclude this chapter by using the literature to inform the creation of a conceptual framework that will be used to underpin the empirical chapters and will allow various forms of infrastructure integration to be situated in an internationally comparative context.

## 2.1 UNDERSTANDING INFRASTRUCTURE

In this section I seek to explore just how infrastructure networks might be conceptualised, arguing that there are three key features that underpin their analysis. First, following an examination of the various definitions of 'infrastructure', I argue that infrastructures should be viewed as *socio-technical systems*, or systems that are both socially constructed and society shaping. Second, these socio-technical systems are embedded in wider *institutional* contexts that can influence and shape their creation, development and governance. Third, while infrastructure networks can cross national and international boundaries, I argue that there are particular issues at the *urban* scale that are

important for infrastructure management. These three key features of infrastructure will help to underpin the creation of the conceptual framework in Section 2.3 and will help shape the nature of the research questions outlined in Chapter 3. I begin this section with an exploration of the definitions of infrastructure.

### 2.1.1 Infrastructures as Socio-Technical Systems

There are different definitions of an 'infrastructure' depending on what entity is being investigated in what discipline. Torrisi (2009) argues that, although there is a general consensus on how important basic infrastructures are, in many studies the concept encompasses different empirical and theoretical entities. The Oxford English Dictionary defines infrastructures as the "basic physical and organisational structures (e.g. buildings, roads, power supplies) needed for the operation of a society or enterprise" (Oxford English Dictionary 2006). The United Kingdom's Centre for the Protection of National Infrastructure (CPNI) defines national infrastructures as those "facilities, systems, sites, information, people, networks and processes, necessary for a country to function and upon which daily life depends" (CPNI undated: para 1). Within this the CPNI includes 13 sectors of importance, such as energy, water, transport, telecommunications, defence, chemicals, finance, food and health. In the United States, the Department for Homeland Security lists 16 critical infrastructural sectors whose "assets, systems and networks, whether physical or virtual, are considered so vital to the United States that their incapacitation or destruction would have a debilitating effect on security, national economic security, national public health or safety, or any combination thereof" (DHS Undated: para 2). This definition includes facilities relating to key commercial, financial and manufacturing sectors, and a separate infrastructural sector relating to dams, water navigation locks and hurricane barriers.

Edwards (2003) argues that, given the heterogeneous and fluid nature of systems and institutions referred to under the umbrella term of 'infrastructure', the concept may best be defined as those systems without which contemporary societies cannot function. Neuman (2006) adds that infrastructures act as "life supports that channel water, energy, information, people, goods, and wastes to and from the objects supported" (Neuman 2006: 3). Many social scientists use the definition developed through the Large Technical Systems (LTS) body of academic work, which sees infrastructures as complex technical networks embedded into society (Joerges 1996). These systems are "capital-intensive and often complex socio-technical organizations that have been deployed to provide for the crucial needs of modern industrial societies" and include the archetypes of "the transportation, telecommunications, energy supply and urban utility networks that have been developed from the second half of the nineteenth century" (Coutard 1999: 8). Many of these large technical systems emerged and developed in the late 19$^{th}$ and 20$^{th}$ centuries in support of urbanisation and latterly suburbanisation via the supply of energy, water and telecommunications and the provision of public and private transportation networks. These networks have become so embedded into the daily lives of urban citizens that it is difficult to imagine a modern developed city without some basic form of resource supply. As Edwards (2003) argues, without large technical systems contemporary societies cannot function.

A number of studies have examined the creation and development of large technical systems as isolated entities, but few have looked analytically at the development of multiple infrastructures taken together as a whole (Edwards 2003, Hughes and Mayntz 1988). In the early 1980s, the historian Thomas Hughes was one of the first social science academics to study the creation and development of infrastructures in general, arguing that the large technical systems that have evolved since the 19th Century tend to follow a well-defined path of innovation, growth, and consolidation. These complex and large technical systems began as small, isolated systems before growing to become "spatially extended and functionally integrated socio-technical networks such as electrical power, railroad, and telephone systems" (Hughes and Mayntz 1988: 5). Hughes claimed there were three main stages of historic infrastructural development: their initial creation by motivated actors; the growth and evolution of networks as the technologies take hold; and consolidation of the successful systems, locking future development into certain pathways. I will now briefly explore each of these three stages.

**The importance of systems builders.** It has been argued that the theories surrounding large technical systems are in many ways agency-orientated, in that they tend to focus on the actions and interactions of social groups and actors (Geels 2007). Hughes (1983) criticised the technological deterministic viewpoint of infrastructures – in which it is technology that drives progress. For Hughes "no technology is, has been, or will be a 'natural force'" moving independently through human history (Nye 2006: 19). Hughes outlined the necessity of 'system builders' who not only invent new technologies or discover how to harness the forces of nature, but who also change the cultural and social landscapes of a society so new technologies can take root (Hughes 1983). These system builders not only work on technological innovations but also help shape markets, standards, consumption practices and regulations. All elements have to align for a new socio-technical system to become successful. Hughes' example of a successful system builder is Thomas Edison who developed and sold not just a light bulb, but an entire system needed to power that light bulb, including the generators and cables necessary for an electricity grid to function. Modern examples include computer manufacturers such as Univac and IBM which became successful due to an early recognition that new technologies should be sold as finished systems rather than as isolated components. Not only did these manufacturers sell CPUs, data processing systems, mass storage devices, keyboards, printers and monitors, but they also offered training, software and business support to early adopters (Edwards et al. 2007).

Early infrastructures (gas networks, water supply and sewage, and electricity) did not begin as complete integrated systems providing universal supply to all citizens in all locations of a territory. Instead they emerged on a largely piecemeal basis, were often spatially and physically separated from each other, varied in their technological components, size and structures, and were mainly found in the more prosperous areas of developed cities. Early developments to create an electricity network, for example, saw major cities such as London and New York supplied by dozens of competing private entrepreneurs, often with their own specific voltage networks and connection systems supplying neighbouring communities. These networks were initially spatially separated, technologically limited and had little interoperability between competing systems.

**Technology transfer and growth:** The next stage in the development of large technical systems is the transfer of technologies across territories and sectors, followed by the growth of the networks. Once an LTS becomes successful it can act as an exemplar network and its technologies and socio-

technical aspects can be transferred to other organisations, cities and countries (Edwards et al. 2007). However, the growing networks are not homogenous. Countries and regions differ in policies, policy priorities, institutional structures and socio-economic cultures, and inevitably those involved in technology transfer will attempt to influence the deployment and development of large systems. This can lead to variations within the socio-technical aspects of what appear to be similar networks, creating what Hughes describes as a 'technological style' (Hughes 1987). While the technologies involved within an LTS may be the same, the local and national identities of networks are important. As Niosi and Bellon argue, while national systems may converge there are also important "different natural factor endowments, cumulative effects of industrial organization and specialization, different national stocks of knowledge [and] different national economic and political institutions" (Niosi and Bellon 1996: 156).

**Consolidation:** The next stage of the LTS development process leads to the consolidation of successful networks, but it is rare for one system to win total victory over its competitive rivals (Edwards et al. 2007). Nevertheless, the consolidation phase does lead to the adoption of technological and engineering standards, an increasing level of interoperability between competing networks, and increasing forms of territorial and technological integration. While the early networks were small-scale, piecemeal, and often highly-splintered, the consolidation phase can see networks transform into large national and international systems. National energy, transportation and telecommunication networks become embedded in urban life; regional water and waste removal services shift in focus away from network growth and towards improving service quality; and technological gateways emerge between networks to allow heterogeneous technical systems to interoperate (Edwards et al. 2007). Small companies merge to form larger ones and a process of path dependence locks-in the early choices made in technologies and user practices. Infrastructures become part of much larger, nationwide networks and become spatially connected technical systems linking urban centres across long distances (Tarr 1999).

Many of the modern infrastructures underwent this process in the mid-20$^{th}$ Century and large technical systems became vital public services. The earlier myriad of technologies, standards and pricing structures led to calls for the networks to be universalised and 'integrated', and after their initial development energy, water, gas and transportation networks became natural monopolies either placed under public ownership or private monopolies governed under heavy regulation. The initial challenge for modernist planners and state authorities was to try to standardise the competing large technical systems into services that could be homogenised and offered to all members of the public as part of plans to promote a cohesive community (Graham and Marvin 2001). State regulation increased and national and regional monopolies emerged to further establish the dominance of the large-scale, centralised model of infrastructure provision (Leach et al. 2015). Graham and Marvin (2001) argue that this integration of networks and universalisation of services was a key component of the modernist infrastructure ideal:

> "From the initial, general picture of heterogeneous, partial networks, of poorly inter-connected 'islands' of infrastructure and of extreme, uneven development in the infrastructural capacities of different urban spaces emerged, over the period 1850-1960, single integrated and standardised road, water, waste, energy and communication grids covering municipalities, cities, regions and even nations. These were legitimised through notions of ubiquity of access, modernisation and societal progress, all within the rubric of widening state power." (Graham and Marvin 2001: 41).

Supply-led notions of expand and upgrade for energy and water networks, or predict and provide for transportation networks, "encouraged the development of large-scale, centralized infrastructure systems of extensive physical networks drawing on increasingly distant natural resources" (Guy, Moss and Marvin 2001: 5). The integration of infrastructures is therefore not only a contemporary problem, but has been a normative concept present within infrastructural discourses since the initial creation of large technical networks.

Drawing on the above literature, we can begin to view infrastructures as *socio-technical systems* – technologies that rely on a variety of externalities to become normalised, to develop and to be accepted within a culture (Bijker et al. 1987). Infrastructural networks (and the processes that influence them) do not exist outside of human society. Rather they are examples of systems that are both socially constructed and society shaping (Hughes 1987). They are made up not only of physical artefacts (cables, pipes, power plants, roads, rail) but also form a 'cluster of elements' of organisations and institutions (firms, banks, utilities, research universities) rules, regulations, and natural resources (Bijker et al. 1987, Geels and Kemp 2007). Electricity grids, transportation systems, telecommunication networks, waste systems and gas pipes should not be examined in purely engineering terms from a technological determinist viewpoint. Indeed, Filion and Keil (2017) argue that viewing infrastructures as mere technologies can 'depoliticize' decision-making with the various component parts of a system becoming the exclusive purview of 'experts'. Instead infrastructures should be seen "as a set of social, cultural, economic, and political interests fused together with technology, rather than a 'black box' of generators" (Sovacool 2009: 4501).

Borras and Edler (2015) describe socio-technical systems as "articulated ensembles of social and technical elements which interact with each other in distinct ways, are distinguishable from their environment, have developed specific forms of collective knowledge production, knowledge utilization and innovation, and which are oriented towards specific purposes in society and economy" (Borras and Edler 2015: 11). This thesis utilises a socio-technical system perspective for four reasons: the ability it offers researchers to examine the co-evolution of technology and society; the similarities of the challenges and opportunities of various socio-technical systems; the recognition that knowledge and experience are important to infrastructural development; and the ability to consider 'integration' both within and between socio-technical systems. Before concluding this section, I will briefly examine each of these points.

First, a socio-technical perspective allows researchers to examine the co-evolution of technology and society (Geels 2004). Viewed as socio-technical systems, infrastructures have their own regional technological styles that emerge from the socio-political structuring environment, and cities will experience and react to challenges differently with varying capacities for response emerging from historically distinct infrastructure configurations (Hodson and Marvin 2010a). A socio-technical perspective also allows researchers to avoid becoming embroiled in the actor versus structure debate by framing innovations as a product of the interactions between the two. Technology pathways are chosen (or evolve) as a result of the combination of individual and collective acts, depending on the diffusion of knowledge through organisations and wider society as well as pressures emanating from advocacy coalitions pushing desired pathways (Rizzi, van Eck and Frey 2014). Actors are not entirely free to act as they wish. They are constrained (but not always prevented) by the rules and institutions that exist within any society. More than this, actors may behave according to their *beliefs* about what rules and regulations may exist and the social norms

that structure their daily lives. While written rules and conventions are important in structuring behaviour within a society or organisation, it can also be an actor's interpretation of those norms that can lead to differentiated technological path trajectories. As Monstadt (2009) outlines:

> "…once such a configuration of technological artefacts, with its related scientific knowledge base, engineering routines, user practices, skills and procedures, regulatory institutions, etc, has become stabilized, it guides innovation processes, limits the degree of technological variation, and constitutes a restricting, enabling, or even stimulating context for political governance" (Monstadt 2009).

Second, many of the infrastructures that can be classified as socio-technical systems share common problems such as "the challenges of congestion and inadequate capacity; financing of facilities; opportunities for improved management due to enhanced real-time operability; institutional and standards 'lock-in'; and understanding trade-offs between optimality and robustness" (Hansman et al. 2006: 7). Nearly all the infrastructures in use in the developed world are managed and organised around institutions and structures that emerged in the late nineteenth and early twentieth century with incremental, ad hoc, and largely path-dependant changes in technology, markets, and regulatory processes (Hansman et al. 2006). While the growth of cities has often depended upon new technological innovations and the development of large centralised infrastructure networks (Gann et al. 2011), many cities have evolved without holistic strategic planning of their networks and thus share common problems. Sewers that were built more than a century ago still serve state-of-the-art hospitals and research centres while driverless cars and high-speed trains still travel on decades-old rails and roads with very simple and limited capabilities. As such, it is useful to explore the governance of these utilities together, rather than as isolated networks separated from each other, and an analysis that examines the governance of multiple utilities may provide more fruitful research than one that examines a single sector.

Third, a key factor inherent in the socio-technical system approach is interpretive flexibility, in that there is "flexibility in how people think of or interpret artefacts, but also that there is flexibility in how artefacts are designed" (Elle et al. 2010: 137). The *knowledge* that people have about what it is they are doing is an important part of a socio-technical system: for example, the 'know-how' involved in using smart energy meters; boiling just enough water to make a single cup of tea; or using high gears to conserve fuel when driving a car. It is not just technology that is socially-constructed and its use influenced by culture and routine, but the scientific knowledge that lies behind technological innovation is also an element in a socio-technical system (Pinch and Bijker 1984). Who decides what problems should be solved? What influences their decisions and how do their actions impact upon infrastructural development? Key to this thesis is the identification of what the concept of infrastructure integration means to interviewees; where their knowledge about it comes from; how free they are to move towards (or away) from integration; and what institutional frameworks constrain or enable their actions.

Fourth, viewing infrastructures as socio-technical systems allows us to examine the possibilities for integration both *within* systems and *between* systems. Each system has its own values, culture, politics, economics and governance arrangements, and one question of importance is how various forms of 'integration' could impact on each of these elements. For example, the energy network is facing challenges in terms of how to integrate new technologies (such as decentralised generation)

into the existing centralised grid. However, these challenges cannot be answered through purely technological solutions. The governance of large centralised networks threatened by disruptive technologies, the economics associated with the deployment of small-scale low cost renewable energy sources, and the organisational structures of existing companies tasked with network management are all issues which need to be taken into consideration when discussing infrastructure integration. If we introduce an analysis of integration *between* socio-technical systems – such as the widespread adoption of electric vehicles, potentially changing both the energy and transport sectors – then the situation becomes even more complex.

While it is important to view infrastructures as socio-technical systems, one issue that needs to be addressed is how these systems are situated into wider real-world contexts. Infrastructures do not exist independently of human society. Instead, they are embedded into various institutional structures, can operate within differing political contexts, and can exist at numerous overlapping geographical scales. In the next section I argue that the institutional context of any socio-technical system is key to how they are created, evolve, are managed and are interacted with.

### 2.1.2 The Institutional Structuring Environment

The second feature that is important when conceptualising infrastructures is the institutional context in which socio-technical systems are governed and managed. Socio-technical systems are themselves nested within wider governance networks that can operate regionally, nationally and internationally, and in this section I argue that infrastructures are embedded within their wider institutional environment that can direct future developments, enable certain technological pathways and potentially constrain the nature of decisions taken by actors.

Key to this thesis is a recognition that infrastructures are more than just a collection of technologies. In the previous section I outlined the importance of viewing infrastructures as socio-technical systems: networks that are both socially constructed and society shaping. While this concept is useful when examining individual networks (such as in researching how producers, consumers, and regulators interact with technological innovations occurring within energy or water networks), to research multiple infrastructures it is useful to broaden the argument to include wider institutional frameworks that can structure multiple socio-technical systems. These institutional factors can influence how large networks are created, evolve and are governed, and the extent of infrastructure integration depends upon various factors at a national, sub-national and local level that are historically embedded but may be subject to change. This is important as it has been argued that the greatest challenge in moving towards sustainable infrastructures is not technical, but organisational and institutional. Moss et al, in discussing the water industry, write:

> "Globally, we avail of the expertise to tackle all but the most intractable technical problems in providing adequate drinking water and securing a healthy environment. Problems in rendering water services more sustainable – economically and socially, as well as environmentally – relate far more frequently to organisational issues, such as unsuitable legal frameworks, incompatible actor interests, or inadequate economic incentives" (Moss et al. 2009: 16).

The institutional structuring environment plays a key role in what, if any, forms of infrastructure integration may develop. What may seem to be highly efficient and promising technologies may fail to become standardised if they are not adapted to fit their institutional environment. Citizen behaviour, norms and cultural practices all play their part in how successful technologies can be. Not only do countries have different electoral systems, political, legislative and executive functions, and socio-political environments, but they also differ in how concepts of the roles of the state filter through regional and urban governance networks and infrastructural management systems. It is Lorrain's argument (2005) that "as we start to develop a concrete analysis of [infrastructure] policy, we encounter the reality that any analysis of political and organizational forms of urban government is immediately complicated by the need to consider the institutional architectures through which these productive tasks are delivered" (Lorrain 2005: 232).

Institutions are an important element in the dynamics of technological change and the structuring context of any state or city is an important factor for researchers (Bathelt and Glückler 2014). As Healey argues (1998), within Europe the governance traditions in different countries are highly diverse. They "vary in their legal forms and administrative cultures, the pattern of resource flows, the relations between levels of government, the relations between public sector, private sector, and community involvement, and the way expertise is used" (Healey 1998: 1532). The institutional environment has been described as a way of structuring human interactions, the 'rules of the game', the regulatory framework and the constraints of human behaviour (Hall, Foxon and Bolton 2016). North (1990) defines institutions as "the rules of the game in society or, more formally, the humanly devised constraints that shape human interaction" (North 1990: 3). These are not fixed: despite the presence of written constitutions in many western democracies they can evolve, break down, and alter in often unexpected ways. It is often when new technologies are developed and adopted that institutions face crisis and are forced to adapt to a new reality (Mahoney and Thelen 2010). One example includes the failure of existing regulatory regimes to tackle growing issues of digital piracy associated within the rise of peer-to-peer networking. Clingermayer and Feoick (2001) describe three main functions carried out by institutions (2001). First, institutions offer incentives or disincentives for citizens to engage or behave in certain ways, such as 'sin taxes' on unhealthy items such as alcohol and cigarettes (O'Donoghue and Rabin 2006). Second, they reduce uncertainty to allow actors to take decisions with the knowledge that abrupt disruptive events are rare, which allows their actions to take root in organisations and diffuse in wider society. Third, they provide stability and can "induce patterns within social phenomena that otherwise would appear meaningless" (Mahoney and Thelen 2010: 3).

The institutional structuring context can be characterised by a resistance to change due to the mutually reinforcing technological and institutional structures of coevolving domains, such as linkages between the various infrastructure sectors (Rohracher and Späth 2014). Engineers within the same field or organisation may share similar outlooks and views on how to tailor solutions to common problems. The forms of infrastructure integration that may exist within the three case study cities, and the extent of its progression, will be dependent upon the shared discourses and beliefs of the actors involved within infrastructural governance networks. As Geels argues, organisations and actors "remember by doing" (Geels 2002: 1259). If the common discourse within an urban regime is against integration, then it is unlikely we will be able to see forms of integration on a wide scale. If there is a common argument for integration, what form it will take, the

importance of its progression and the likelihood of its outcome will all be dependent upon the strength and stability of the concept inherent within the institutional discourse.

If we accept that socio-technical systems are embedded within their institutional environment, then logically we have to accept that there will be variations between systems that, on the face of it, should be identical. Hughes (1983) describes this as a 'regional technological style'. Infrastructures within the United States will experience different opportunities and challenges than infrastructures within Brazil. The histories, politics and economies of the two countries are radically different, the stages of technological development vary, and the ability for governing organisations to undertake large centralised projects will differ based on the budgets available and the ability of actors to impose change. Similarly, consumers within urban London may interact with their infrastructure networks in different ways than their counterparts within rural Africa – the ability for consumers to choose between competing providers, the varying services and coverage areas on offer, and the power relations between actors could vary drastically.

As such, it has to be accepted that there are variations between the institutional environments that exist between cities and between countries. The Varieties of Capitalism literature (VoC), developed by Hall and Soskice (2001), is one school of academic thought that has attempted to differentiate between various countries, classifying capitalist economies based on rather simplified characteristics: corporate governance, workforce training, inter- and intra-firm relations, state assistance, industrial specialisation and comparative advantage. For Hall and Soskice there are two types of capitalisms: liberal market economies (LMEs) such as the United Kingdom and the United States in which the activities of actors are coordinated through market institutions characterised by profit-driven, competitive and 'consumer choice' orientated state governance; and coordinated market economies (CMEs) such as Germany or Denmark with a stronger focus on joint state and business interactions. The VoC approach can be criticised for dividing the capitalist world into just two categorisations, simplifying or even overlooking the myriad of differences between the countries defined as LME or CME. The United Kingdom, for example, allows domestic oil produced from the North Sea basin to be sold on world markets. Whereas, up until 2016, the United States did not, instead pursuing a policy of domestic energy security over free international trade, suggesting a level of coordinated market intervention more suited to CMEs than LMEs. While the VoC approach is rather simplified – grouping European and American capitalism into just two types – it does recognise that the institutional context within a country can determine the trajectory of economic and technological development (Boschma and Capone 2015).

Lorrain (2005) adds to the debate with a more nuanced and contextual examination of the varieties within Europe and their impact upon infrastructural concerns. He claims attempts to integrate markets, regulations and infrastructures across the continent serve to "highlight these profound differences between various ways of organizing a market economy", adding:

> "The reason is simple: more than in any other sector, institutional choices concerning these [infrastructure] networks are continuously expressing the complex influence of the political sphere, markets, firms and weighty anthropological factors. These differences — not very visible in the past, before the creation of a major market related to industry, banking or market services — have now come fully into view" (Lorrain 2005: 231).

Key here are the interactions between nation states, markets and society; the national or regional ideologies that may favour specific institutional arrangements over others (such as preferences towards privatization or public ownership of infrastructures); and the filtering and rate of diffusion of policy and industrial strategy throughout society. I will explore the institutional environment of the United States, Germany, and the United Kingdom more fully in Chapter 4.

So far in this chapter, I have argued that it is important to view infrastructures as socio-technical systems, and that these systems are embedded within an institutional environment that can shape their future trajectory. In the next section I outline the third important feature of infrastructure research, namely that it is at the *urban* scale that infrastructural interventions may have the most impact.

### 2.1.3 The Urban Dimension

It has been argued that, despite its criticality and pervasiveness, urban infrastructure "is an under-explored area of critical urban research, policy and practice" (Steele and Legacy 2017: 1). Infrastructure networks and urban areas are inexplicably linked – indeed there has been an assumption of an "infrastructural ideal as both the basis and engine of modern urban society" (Filion and Keil 2017: 9). Yet, it is perhaps strange that, while urban areas are dependent upon the continuous operation of efficient infrastructural networks, in some countries city planners have largely been excluded from decisions over the creation and development of networks: many actors involved in infrastructural provision tend to neglect the urban dimension and often see cities as nothing more than the end points of complex supply chains (Rutherford and Coutard 2014). This lack of attention is reflected in much of the academic literature. As Rutherford and Coutard highlight (2014) over the past 50 years only 26 papers published in the journal Urban Studies mention 'energy' or 'electricity' in their abstracts. Despite the links between cities and infrastructures in academic research the two have been largely ignored as a coevolving socio-technical system (Monstadt 2009, Coutard 1999). In this section, I seek to explain the importance of the *urban* to infrastructure studies, beginning with an exploration of what constitutes an urban area.

There is considerable confusion and debate over just what constitutes a city or an urban area. Similar to the concept of 'integration', the term 'urban' can be diffuse, contested, and applicable to a wide variety of academic studies. The debate on what is 'urban' has been ongoing within critical urban studies for decades (Keil 2003). In 1971 Stephan Thernstrom criticised the growing use of the term 'urban' in academia, arguing against the emerging discourse that 'urban studies' reflected a distinct and specialized field of inquiry:

> "It is important… to recognize that most of the subjects that have preoccupied the new urban historians – the flow of population from country to city, patterns of social stratification and social mobility, the social consequences of technological change, the distribution of property and power, the position of ethnic and racial groups, and so on – are not confined to the city, and should not be approached as if they were. They involve the workings of the society as a whole,

though of course they have different manifestations in communities of varying sizes and types" (Thernstrom 1971: 361).

The concept, however, has continued to be used widely both within and outside academia. Weeks (2010) defines an urban area as a "spatial concentration of people whose lives are orientated around non-agricultural activities" (Weeks 2010: 34). Weeks also accepts that the divide between rural and urban is becoming increasingly blurred due to an increasing urban population and technological innovations. Studies of urbanism can be complex as the distinctions between urban and rural may not necessarily be a dichotomy (Hall, Kaufman and Ricketts 2006). Rural communities in one area can differ as much from rural communities in another as much as they do from large cities.

In a review of urban resilience Meerow, Newell and Stults (2016) found that many academic papers are vague about what constitutes an urban area or a city with studies variably describing cities as "complex systems", being composed of networks, or being composed of both systems and networks. In urban ecology studies the term 'urban' is often defined as a 'social ecological system' in which human and natural processes interact with each other (Friend et al. 2016). These studies draw from the literature on natural resource management and while there are attempts to use clearly defined geographic boundaries, social groupings, and accountable political systems, the approach has been critiqued for overlooking the dynamics of politics and power (Friend et al. 2016). The transitions literature, meanwhile, defines the urban as a socio-technical network that can help create and direct technological change, comprised of actors, technologies, infrastructures and multi-level processes of innovation and change (Hodson and Marvin 2010a). These scholars recognise that distinctions between the city and its hinterland can be highly problematic: the relations are interdependent, and the boundaries between them are blurred, so where does a city end and its surrounding suburban or rural environment begin?

Yet, cities and urban areas are becoming increasingly important in infrastructural studies, for three reasons: economic and population growth, the historical development of infrastructures and their linkages with urban areas, and the ability for cities to spur technological innovations. I will now examine each of these three reasons in turn.

First, economic and population growth is becoming increasingly concentrated within urban areas. As such, any attempts to tackle problems related to climate change or ageing infrastructural networks will necessarily be geographically concentrated in urban areas. It has been argued that urban responses to climate change both configure and are configured by infrastructure networks (Bulkeley, Castán Broto and Maassen 2014b). Today more than half the world's population is resident within urban areas and this is expected to increase to 66 per cent by 2050 (United Nations 2015). Countries in North America and Europe are amongst the most urbanised in the world: 82 per cent of people in North America lived in urban areas in 2014, compared to 73 per cent in Europe. Cities are key sites for infrastructural governance and most initiatives seeking to improve sustainability or resilience may be more effective if deployed in urban areas, due to the density and intensity of infrastructural interactions there (Neuman 2006). The United Nations argues:

"Trends in urbanization are integrally linked to sustainable development. With good planning and governance, the increasing concentration of people in urban settlements can facilitate economic and social development, while also offering opportunities to mitigate the adverse impact of consumption and production on the environment. However, rapid and unplanned urban growth

threatens sustainable development when the necessary infrastructure is not developed or when policies are not implemented to protect the environment and ensure that the benefits of city life are equitably shared" (United Nations 2015: 1).

Cities account for about 80 per cent of the world's GDP, two thirds of primary energy demand and about 70 per cent of energy-related carbon dioxide emissions (IEA 2016). As the International Energy Agency observes:

> "The world's energy future is inextricably linked to its urban areas. High urban concentrations of people and economic capital, and the characteristics of urban buildings, transport systems, industrial processes and energy infrastructures, all heavily influence global energy use. As of 2015, 3.9 billion people were living in urban areas, representing 52% of the global population of 7.3 billion. By 2050, the world's urban population will reach 6.3 billion, or two thirds of the projected global population of 9.5 billion" (IEA 2016: 138).

A second reason why cities are important to infrastructural research is that it is arguable that it was the creation of large technical systems in the late 19th century that allowed for the evolution of the large cities that we see today. Neuman (2006) argues that infrastructures have 'empowered' cities and transformed them from the small city-states that existed in classic Greece to the centres of economic, social and cultural production that exists today, adding if the "twentieth century was the American century, the twenty-first is the urban century" (Neuman 2006: 8). Infrastructures and cities are inextricably linked and infrastructures are the key mediators of urban life (Graham and Marvin 2001). Urban areas are themselves systems that provide the setting for infrastructural 'flows' of people, capital, cultures and technologies (Williams 2014). The new technologies, transportation infrastructures and energy and water networks allowed for the expansion of cities both vertically and horizontally, and for the first time allowed for the creation of the 'megalopolis' (Lorrain 2001). While today more than half of the world's population live in cities, in 1850 only two per cent of people lived in cities of more than 100,000 people (Weeks 2010). Indeed, the provision of infrastructure is an "essential condition for the concentration of populations and all forms of activity in society" (Filion and Keil 2017: 9). Modern cities have become dependent upon network infrastructures. Energy and water are often produced and collected in far off regions and transported vast distances to be consumed in cities, using an almost invisible or 'black-boxed' system of infrastructure networks (Rutherford and Coutard 2014). Gann et al (2011) list several examples to demonstrate the links between the growth of cities and large technological networks:

> "The development of waterpower and construction of canals following the Industrial Revolution encouraged the growth of industrial cities, such as Manchester. Steam engines and railways in the nineteenth century facilitated the urban production and distribution of industrial products on an unprecedented scale. Productivity depended on the construction of systems of sewerage and water works critical to the survival of large agglomerations of people. The electrification of power and rail transportation in the early twentieth century transformed people's capacity to commute within cities beyond walking distances. High-rise construction techniques increased the amount of available space in cities for offices, factories, and other accommodations. Rapid expansion of the automotive industry in the early and middle decades of the twentieth century fundamentally changed cities, with the growth of suburbs and the construction of highways and airports, along with the developing airline industry, contributing to the means of communications associated

with cities. Innovations in food processing, distribution, and sales – such as in refrigeration, packaging, and the development of supermarkets – provided the necessary sustenance to growing urban populations (Gann et al. 2011: 2).

Historically, three stages of infrastructural development that have led to the modern large city can be identified (Lorrain 2001): infancy, expansion and generalization. First, the *infancy of the network* allows a few affluent early adopters to become connected during a period of experiment and invention. Second, the *expansion of the network* is facilitated by public policies that increase the supply of services by establishing priorities, setting technological standards and creating institutional frameworks that direct and embed the networks in urban life. Key here is the centrality of the state in directing investment and coordinating construction and development. The third stage is *generalization*, or the diffusion and extension of large networks, creating a socio-technical configuration of practices both before and beyond the meter. While these stages of infrastructure development are similar to those outlined by Hughes, Lorrain directly links the development of large technical systems to the growth and survival of modern cities. Growing infrastructures have allowed for the creation of the 'gigacity' characterized by the development and circulation of associated, goods, products and services.

The third reason for the focus on urban infrastructure is that urban areas can act as important experimental labs for technological innovations and novel forms of infrastructural provision, which are becoming increasingly important in an era of state restructuring and low carbon experimentation (While, Jonas and Gibbs 2010). Many scholars have identified the importance of cities acting as test beds for large networks (Broto and Bulkeley 2013, Bulkeley and Castán Broto 2013, Coenen, Raven and Verbong 2010, Karvonen and van Heur 2014, McLean, Bulkeley and Crang 2016). Cities can act as motors of sustainable development with large sources of potential consumers and they act as vital consumption nodes in global production networks. Despite shifts towards privatised and splintered networks, local city authorities are often still responsible for the growth and spread of large technical networks. They are responsible for zoning and planning codes, the management of transportation networks, land use planning and, in many cases, offer direct provision of infrastructural services. Interventions may also be effective within urban areas as many infrastructures within cities often share a common physical space: water and gas pipelines, electricity networks and sewage systems are often located underground necessitating a form of pragmatic integration between organisations seeking to dig up the highways and road networks (Wilbanks and Fernandez 2014).

### 2.1.4 SUMMARY

In this section I have sought to outline the main features that are important when conceptualising infrastructural networks. First, I argue that infrastructures should be viewed as socio-technical systems, systems that both socially constructed and society shaping. Second, these socio-technical systems are embedded within their institutional environments, and these environments vary between cities and nations. Third, it is at the urban scale that interventions within infrastructure networks may have the most impact, and which should be the subject of academic research. These

three features will help to underpin the conceptual framework to be developed in Section 2.3. In the next section, I seek to build on this conceptualisation of infrastructure with an examination of the concept of infrastructure 'integration'.

## 2.2 Understanding Infrastructure Integration

In the previous section I outlined the basis for viewing infrastructures as socio-technical systems that are embedded within their institutional environments and are interlinked with urban areas. In this section I seek to move the argument further by examining what the 'integration' of infrastructures may actually entail, asking why calls are being made for 'integration' to take place, and seeking to understand what form this 'integration' may take. I begin this section with an examination of the 'splintering urbanism' literature that helps set the scene for why contemporary calls for infrastructure integration are being made. Next, I conduct a review of the infrastructure integration literature, exploring initial definitions for the term before examining the integration literature emerging from 'nexus' studies, the system of systems approach to infrastructure, and possible organisational forms of integration. This literature will then help inform the conceptual framework in Section 2.3. I begin this section with an outline of the 'splintering urbanism' theory.

### 2.2.1 Splintering Urbanism

Although the Large Technical System model developed by Hughes ends at consolidation with the establishment of large-scale, integrated networks, Edwards et al (2007) argue that a further stage can be added: the 'splintering urbanism' theory developed by Graham and Marvin (2001). Splintering urbanism examines the consolidation of infrastructures as modernist integrated systems and their evolution into more splintered, liberalized and often sporadic networks. Changes in the global landscape that have occurred since the 1960s have led to a shift away from the modernist ideal of standardised and homogenous technological networks towards a more varied, liberalised, often privatised, heterogeneous infrastructural landscape offering differing services to consumers. As Coutard writes:

> "… from the late 1960s, this [modern infrastructural] ideal was progressively undermined by a combination of powerful factors: the urban infrastructure 'crisis'; changing political economies of urban infrastructure development and governance; neoliberalism and the withdrawal of the state; economic integration, urban competition and the imperatives of global–local connectivity; the development of infrastructural consumerism; the collapse of the comprehensive ideal in urban planning; new urban landscapes; and 'new structures of feeling'" (Coutard 2008: 1815).

These shifts have occurred in parallel with various underlying capitalist forces helping promote a form of 'infrastructural consumerism' within networks (Rutherford 2008, Coutard 2008). Citizens can now choose their infrastructural supplier based on cost, quality or reliability. In many western

developed countries, this liberalisation has trickled through to nearly all areas of society. This has led to a "radical sociospatial reorganization of cities" (Monstadt 2009). There is no longer a universal view of how to roll out infrastructures within cities and the changes in cultural, political, social and economic ideologies has led to the "demise of the idea that it is possible or desirable comprehensively and rigidly to plan 'order' and 'rationality' into the form, structure and life of cities" (Graham and Marvin 2001: 92). Today, infrastructures are often managed on a piecemeal or incremental basis, often developed by large private companies and there has been a shift in focus away from supply-driven infrastructures towards more demand-orientated management priorities. As an example, to receive favourable conditions on capital markets, cities are expected to keep expenses low and revenues high, leading to officials favouring infrastructure networks that can 'pay for themselves' (Kirkpatrick and Smith 2011). As such cities are now in competition with each other to attract outside investment, they make themselves attractive to large multinational firms willing to invest private capital and they must demonstrate that proposed projects can provide a viable return. The creation and maintenance of networks is often delegated to private companies, specialised arm's-length organisations, and public-private-partnerships. This can lead to financiers to 'cherry pick' more affluent populations of consumers while the less well-off are left with poorer, basic levels of services. This has created 'bypass strategies' or "strategies that seek the connection of 'valued' or 'powerful' users and places, while at the same time bypassing 'non-valued' or 'less powerful' users and places" (Coutard 2008: 1816). In some areas infrastructures can be run in discreet 'silos' without any wider considerations as to how developments may impact other networks or the surrounding urban environment. The 'integrated' networks associated with the modern infrastructural idea are now 'splintered', from other networks and from wider society.

These processes involve both a simultaneous unbundling and reintegration of infrastructure networks within and between urban areas. Gated communities cut off from their surrounding localities are now likely to be better connected technologically to similar affluent areas in cities around the globe than they are to their surrounding neighbourhoods. Privatised companies focus their attentions and high-value products on affluent members of a community, 'splintering' networks and leading to inequalities and uneven services. Graham describes these as 'premium networked spaces' with "new or retrofitted transport, telecommunications, power or water infrastructures that are customized precisely to the needs of powerful users and spaces, whilst bypassing less powerful users and spaces" (Graham 2000: 185). High value localities have access to real time flows of information while in some areas pre-payment meters have allowed some utilities to "withdraw from having any direct contact with poorer users at all" (Graham and Marvin 2001: 298).

This uneven development of infrastructures is creating new "urban landscapes of innovation, economic development and cultural transformation while at the same time intensifying social and economic inequalities within cities" (Knox and Pinch 2014). This has led to public authorities losing knowledge about their own urban landscapes and a splintering between infrastructure networks, urban planning and social welfare (Rutherford 2008). Research using the splintering urbanism approach has found numerous examples across the developed world. In Stockholm, Sweden, the unbundling of the various networks and the privatisation of utilities has led to urban planners losing specialist knowledge about the city – "when the energy company was split from the city, the city was also split from its knowledge" (Rutherford 2008). In Buenos Aires, Argentina, the lack of central authority control has led to the creation of a myriad of different and unique transportation and

water networks with many homeowners installing their own stop-gap technologies in an attempt to create their own networks (Dupuy, Van Schaik and Klaasen 2008). In Durban, South Africa, the roll-out of information and communication technologies is less directed from a central planning authority for city-wide benefit, but more ”subject to deal-making and the co-ordination of vested interests” (Odendaal 2011: 2395). However, the splintering urbanism theory tends to overlook the benefits offered in the new infrastructural landscape. In Berlin, for example, a number of homeowners and workers from the city’s parks department have taken over from the water utility in managing their own rainwater collection, reducing the amount of runoff into the city sewers and reducing the local flood risk. Elsewhere in the city a number of tenement buildings have introduced their own separate water meters “regarded by the tenants as one of the most useful green technologies, because of the opportunity to reduce their water bills not available under the traditional charging system” (Guy et al. 2001: 110). Generally, however, market forces are leading to higher quality “services where demand is great and solvent, and services of lesser quality, or even inexistent, where demand is considered insufficient” (Offner 2000: 175). As MacLeod (2011) argues:

> “At the risk of generalising across the globe, the political temperament has tended to favour a withdrawal of ‘interfering big government’ or a ‘centralising state’ as discourses of ‘empowerment’, ‘freedom’, ‘decentralisation’, ‘devolution’ and, most recently in the UK, ‘localism’, are routinely and blithely trumpeted in political mantras at local, national and supranational scales” (MacLeod 2011: 2458).

It is in this context that contemporary calls for the ‘integration’ of infrastructure networks are being made. The Keynesian welfare state of the 1960s and 1970s was well resourced and orientated towards the steady supply of services with a state guarantee of universal provision. Today, however, the discourse surrounding infrastructure integration appears to be more focused on ‘sweating’ the existing infrastructural networks to do more with less (for example, to allow existing networks to cope with decentralised energy generation), reducing investment and costs in an age of government austerity and economic neo-liberalism, and reducing resource usage to meet climate change goals.

There are some criticisms of the splintering urbanism approach. First, as Graham and Marvin themselves admit, not “all networked infrastructures in all places are somehow moving *en masse* from an era of standardised coherence to one of splintered fragmentation” (Graham and Marvin 2001: 385). It is difficult to find a city that has ever developed a fully homogenised and universal network. There have always been (and always will be) pockets of deprivation within regions that suffer from poor connectivity, even more so in the developing world. The theory fails to adequately explain the differentiated urban arenas that exist across the developed world: for example, the infrastructural splintering and rebundling occurring within rural North America is operating under a different political-economic structure with different outcomes than similar infrastructures in urban Europe.

Second, the theory views integration as a normative ideal that overlooks the complexity of urban contexts. It may be that small-scale decentralised networks are the most efficient and socially equitable form of infrastructural management for cities in the early stages of developing their systems. What kind of infrastructure integration would be useful in such a situation? How much integration? And how would we know where to look for this integration? It is assumed by many

academics that a 'splintered' network is effectively negative, and something that should be avoided, while 'integration' is viewed as beneficial. In reality, this may not necessarily be the case.

Third, Lorrain (2001) argues that the development and establishment of large infrastructural networks can take decades and he criticises the splintering urbanism approach for focusing largely on the telecommunications sector – a technology that, relative to the energy, water and transportation networks, is still in its infancy. Lorrain also argues against a focus solely on the 'profiteering' model practiced by Anglo Saxon corporations within infrastructural provision. While profit may indeed be a key motivator for service provision within the United Kingdom and the United States, this analytical lens does not necessarily translate to other jurisdictions. In Germany, for example, electricity companies have a degree of responsibility to their surrounding locales and have been embedded within the coal regions of the country for more than a century, while in France concerns are focused just as much on consumer and political satisfaction as on profit (Lorrain 2001: 11).

However, the splintering urbanism theory does offer several advantages for infrastructural studies. First, it seeks to address the structural and historical processes at work in the governance of urban infrastructure networks (Bulkeley, Broto and Maassen 2014a). Scholars recognise that large technical systems are embedded in their environments, institutional structures and socio-political cultures and the approach recognises the importance of macro-level processes that act as structuring contexts for infrastructural management. Second, the approach adds an explicitly urban angle to infrastructural management. In many ways, the arguments developed in the splintering urbanism approach have 'urbanised' the early work on large technical systems developed by Thomas Hughes (Bulkeley et al. 2014a). As argued in Section 2.1, cities and infrastructures co-evolve together.

The splintering urbanism theory does offer an explanation as to why contemporary calls for infrastructure integration are being made. Yet, what is the 'integration' that policy makers and certain academics are calling for? In the next section I will conduct a literature review of the concept of infrastructure integration, beginning with an initial look at how we can define it before a review of the literature in which 'integration' is raised as a concept of interest.

### 2.2.2 Exploring Infrastructure Integration: A Literature Review

The Oxford English Dictionary defines 'integration' as "the action or process of integrating"; 'integrate' is defined as: "1) combine or be combined to form a whole; 2) bring or come into equal participation in an institution or social group" (Oxford English Dictionary 2006: 738). Yet these definitions are too broad to make the term a useful conception for an academic study. Could the practice of infrastructure integration include inviting end users into the planning process for the construction of new power plants, for example; and could it involve creating discussion groups with policy makers from the education and health sectors when promoting renewable energy provision? Once the concept of integration is examined, the term becomes fuzzy, fluid, open to interpretation, and it can often act as a meaningless catch-all phrase to cover the hidden power relations at work

within governance frameworks. Stead (2008) argues there are a variety of words used within the academic literature +which have the same meaning as 'integration', such as coherence, consistency, collaboration, cooperation, and coordination (Stead 2008).

The concept of 'Infrastructure Integration' can be used to encompass a wide variety of meanings. For example, integration is a key normative phrase in the growing 'Smart City' discourse. New 'smart' grid technologies, for example, are being offered as tools to combine electricity and telecommunication networks to offer real-time updates on a home's energy usage, offering the ability to manage small-scale decentralised generation and providing city planners with tools to manage urban supply and demand (McLean et al. 2016). Hybrid heating systems with smart controls offer the potential to integrate gas, electricity and residential heating, combining different heating appliances into one device and switching between them automatically as needed (Heinen, Burke and O'Malley 2016). However, just what forms of integration are needed for smart cities to succeed is not often apparent. Is integration necessary at the regulatory level for smart cities to develop? Or is the integration of technologies implicit within many engineering solutions sufficient? The European Innovation Partnership on Smart Cities and Communities argues there is significant and insufficiently-tapped value in "integrating the various existing and new infrastructure networks within and across cities – be they energy, transport, communications or others – rather than duplicating these needlessly" (EIP-SCC Undated: para 1). The form this 'integration' might take is not defined: but one form could involve "new joined-up approaches" and the "exploitation of modern technologies" – potentially offering a glimpse into two types of integration – organisational and technological.

The scale at which integration could occur is also not discussed, and similarly, the new governance frameworks that may be needed to facilitate forms of integration are often overlooked. For example, the UK Government's Department for Business, Innovation and Skills has called for "integrated and systemic solutions" to solve urban problems, arguing that a £33m Future Cities Demonstrator Program is allowing Glasgow to provide "new integrated services across health, transport, energy and public safety" (Department for Business Innovation and Skills 2013: 18). But again, just how these integrated services would operate within the siloed UK institutional framework is not examined. In practice, there are often tensions between innovation policies enacted at a national level and the political priorities and realities encountered by local governance networks (Taylor Buck and While 2017).

What is clear is that calls for integration are often calls to examine the *interfaces* and the *interdependencies* between and within infrastructure networks. The water and energy sectors, for example, are heavily reliant upon one another and changes in one have potentially significant impacts upon the other (Watson and Rai 2013). The two sectors are already highly integrated in technological terms – Konrad, Truffer and Voß describe the relationship between the two sectors as one of 'functional coupling' involving an input-output relationship, where the provision of one utility or service requires inputs from another utility or service (Konrad, Truffer and Voß 2008). For a hydro-electric power plant to operate, for example, a supply of water is necessary for the production of energy. Similar linkages exist within waste-to-energy plants, where the provision of energy is dependent upon the steady supply of waste. Critically, Watson and Rai argue that interactions between the water and electricity sectors have become more important and extensive over time

with “a strong governance component” influencing the development and the integration of the two sectors (Watson and Rai 2013: 43).

There are a number of areas of academic research in which the ‘integration’ of infrastructure is discussed. These are studies that see infrastructures as a complex ‘nexus’ of interdependencies, such as the nexus of energy, water and food; the systems of systems approach to infrastructure; and research that is examining the potential for organisational forms of integration. I will examine each of these in the remainder of this section, beginning with a review of ‘nexus’ studies.

#### 2.2.2.1 The Energy, Water and Food Nexus

Research on the linkages between infrastructures can be seen in studies investigating the cross-overs between energy, water and food, which attempts to conceptualise interactions between the domains as a ‘nexus’ of interdependencies, tensions and trade-offs. Shortages in one can create problems in another and there have been calls for more integrated planning and decision-making in projects at both the micro and macro scales. Interest in the integrated concept of a water-energy-food nexus (often referred to as WEF) has grown beyond the academic field: in 2011 the World Economic Forum largely kick-started widespread discussion of the issue while citing the importance of the nexus to water security; it became a key theme in the build up to the Rio+20 summit in 2012 (Hoff 2011); the ESRC has funded the Nexus Network (http://www.thenexusnetwork.org/) to finance future research projects; and a Kyoto-based water-energy-food nexus began a project in 2013 with study sites in Japan, Canada, the US, Indonesia, and the Philippines (Endo et al. 2015). While there is no fixed definition of what a nexus entails it has been interpreted as “a process to link ideas and actions of different stakeholders under different sectors and levels for achieving sustainable development” (Endo et al. 2015: 3). Thus, integration appears to be a key goal. It involves the three primary domains of energy, water, and food (Figure 2.1) as highly interdependent sectors: researchers investigating the urban nexus recognise that these and “other resources are interlinked in a web of complex relations where resource use and availability are interdependent” (Leck et al. 2015: 445). It should be noted that while much research has looked at the three domains of energy, water, and food, research variants include the energy, water, and carbon nexus (Venkatesh, Chan and Brattebø 2014) and the energy, water, and climate nexus (Conway et al. 2015). Nexus studies emphasise system-wide approaches rather than isolated siloed thinking with a focus on system efficiency and encouraging the use of socio-ecological and socio-technical perspectives. Calls are made for integrated management and governance across sectors, systems and scales (Leck et al. 2015). As Sharmina et al outline:

> “...the principle aim of nexus thinking is to transcend traditional policy and decision-making silos and develop approaches that build synergies across these sectors. Such a move calls for interdisciplinary and participatory – i.e. involving stakeholders – research and assessment” (Sharmina et al. 2016: 74).

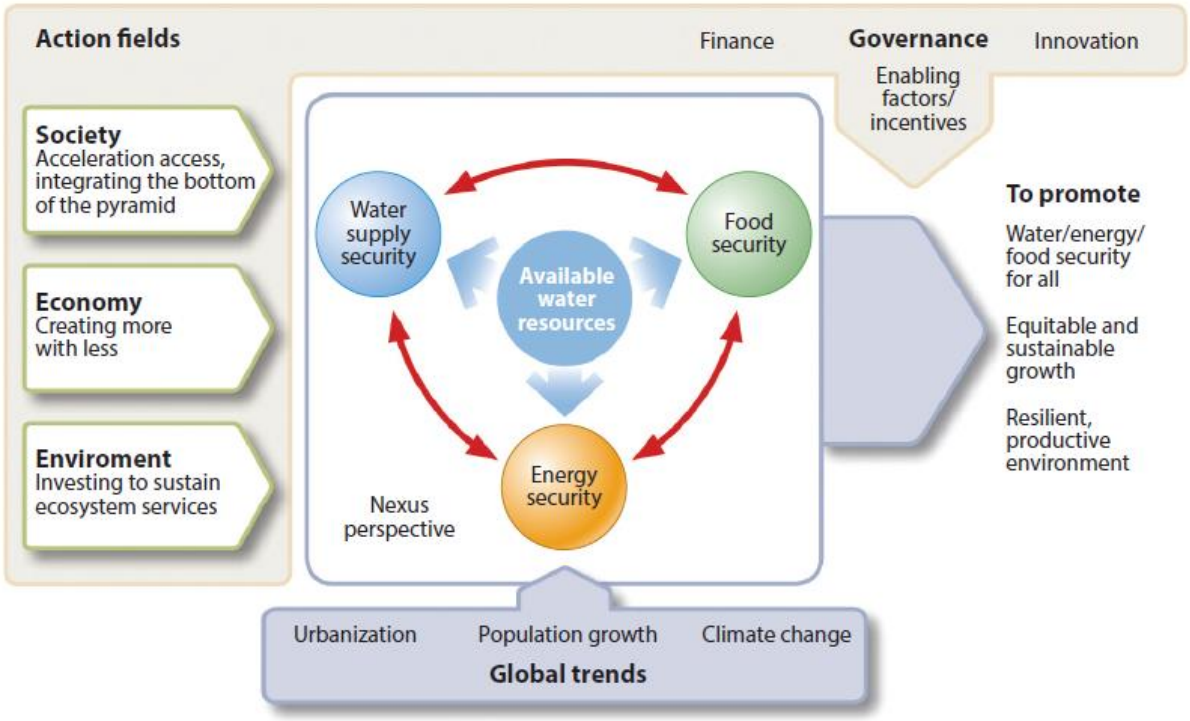


**FIGURE 2-1 THE WATER, ENERGY AN FOOD SECURITY NEXUS (KEAIRNS, DARTON AND IRABIEN 2016)**

Key here is the recognition that infrastructure integration goes far beyond purely engineering or technological solutions. Instead, 'policy and decisions-making silos' are recognised as entities that should be explored and, according to the researchers, challenged. Leck et al (2015) argue that "proponents of the nexus approach emphasise its potential for 'joined-up thinking', recognising connections and coordinating policy and decision-making to minimise negative externalities and unforeseen consequences in tackling interconnected local to global challenges" (Leck et al. 2015: 455).

While proponents highlight the need for integrated thinking between the natural and social sciences, between researchers and decision makers in policy, and business and civil society, many studies remain focused on quantifying the components involved, such as examining how much water is needed to produce a certain amount of electricity or how much electricity is needed to provide clean water to cities (Yang and Chen 2016, Villarroel Walker et al. 2014). Other studies focus on the technological components of systems and their linkages or on improvements to modelling and urban planning (Kenway et al. 2011, Bazilian et al. 2011). Kenway et al (2011) found that there "are far more gaps than solid footing" in research into the connections between water and energy with studies tending to address the individual aspects of problems rather than providing holistic answers, leading to research that collectively represents a "rich hotchpotch that paints an incomplete picture" (Kenway et al. 2011: 1989). Kenway et al (2011) criticise Nexus thinking as inadequately theorised, under-politicised, and lacking in historical and relational perspectives.

#### 2.2.2.2 THE SYSTEM OF SYSTEMS APPROACH

Another body of work examining how integrated and interdependent infrastructures are governed and managed is the 'system of systems' approach. Modern large infrastructures are examples of systems with assemblages "of components that produces behaviour or function not available from any component individually" (Maier 1998: 268). These individual components can be created from a mix of customised technologies, existing or legacy systems, or commercial, off-the-shelf component parts (Sage and Cuppan 2001). The variety of mixtures of these component parts can lead to increasing complexity in the scale of interdependencies and interoperability between infrastructural networks and has forced researchers to examine how a combined or integrated system of systems can operate. Maier describes a system of systems as "assemblages of components that are themselves significantly complex, enough so that they may be regarded as systems and that are assembled into a larger system" (Maier 1998: 269). While the systems may be tightly coupled with large degrees of interdependencies, organisationally they may be governed and managed by separate entities. Each part of the system may have both operational and managerial independence of its components, and each constituent system can operate independently.

There are almost an unlimited variety of networks that could be classified as system of systems: the modern home is one example, with its combination of heating, water supply, electricity consumption and telecommunications provision. Each constituent part (water, electricity, broadband) can be supplied independently through separate competitive providers, yet each system interacts within the home to provide a multitude of overlapping services. Even a modern smart phone may be classified as a system of systems, combining telecommunications, photography, and personal computing. However, the literature recognises that there has to be a clearly defined and researchable definition of what constitutes an infrastructural system of systems. Sage and Cuppan (2001) identify five features that should be recognised through the approach.

1) **Operational independence of the individual system:** Each component system should be able to operate usefully when extracted from the overarching network.
2) **Managerial independence of the systems:** Taking the above point a step further, many component systems are in reality managed independently of each other, they are "generally individually acquired and integrated and they maintain a continuing operational existence that is independent of the system of systems" (Sage and Cuppan 2001: 326).
3) **Geographic distribution:** Systems can operate over vast spatial scales and are still capable of transferring information and data.
4) **Emergent behaviour:** In rather crude terms, the whole can be greater than the sum of its parts, or as Sage and Cuppan write "their behaviours are emergent properties of the entire system of systems and not the behaviour of any component system" (Sage and Cuppan 2001: 326).
5) **Evolutionary development:** Systems of systems are continually changing and evolving. They are never static and evolve "over time and with structure, function and purpose added, removed, and modified as experience with the system grows and evolves over time" (Sage and Cuppan 2001: 326). This a feature of many complex adaptive systems (Rinaldi et al. 2001).

These five features can be used to define an infrastructural system of systems. They are complex networks that may have been "conceived, developed, and deployed as stand-alone systems to address a singular problem" but "can no longer be viewed as operating in isolation" (Keating et al. 2003: 36). For Maier (1998) one key part of any system of systems is the linkages and the interfaces between each component network. In many ways, "interfaces are the greatest leverage, but also the greatest danger" (Egyedi, Vrancken and Ubacht 2007: 29). The systems need to be able to be decoupled from other parts of the overarching system without destroying or damaging emergent behaviours, for example in order to conduct repairs. For Maier, it is the design of the interfaces, rather than the design of the actual components, that guarantee the success of a system of systems. The nodes between the energy and water sectors (such as the couplings between the electricity needed to power water pumps to supply cities with clean water) are more vital to the operation of the system of systems than the type of power used to generate electricity or the technological aspects of the individual water pump.

The system of systems approach has become common in the fields of systems engineering and operational management and the theoretical notion of a system of systems can be used as an exploratory device in fields as diverse as engineering, biological applications, business, society and the environment (Karcanias and Hessami 2010). It has emerged due to failures in the traditional engineering literature to deal with the growing complexities of large technical systems. Keating et al (2003) outline three ways in which the traditional systems engineering literature needs to be upgraded. First, the existing research paradigm has not been developed to address the ambiguity or uncertainty inherent within interdependent and highly coupled systems, and complex systems are not immune to future "shifts and pressures stemming from highly dynamic and turbulent development and operational environments" (Keating et al. 2003: 38). A second problem is the lack of attention given to contextual issues. In reality "context, the circumstances and conditions within which a complex systems problem is embedded, can constrain and overshadow technical analysis in determining system solution success" (Keating et al. 2003: 38). Third, the complex reality of modern networks often necessitates the deployment of partial and upgradable systems that can be changed when the need arises, rather than producing the complete 'whole' systems resistant to change – a process alien to the traditional linear production methods of "concept—complete design—deployment of complete system solutions" (Keating et al. 2003: 38).

Sage and Cuppan (2001) also discuss the concept of a Federation of Systems (FoS), which is defined as a collection of systems with little central power, but rather a coalition of partners based on collaboration and coordination. These include loosely coupled organisations that can work together to achieve shared goals, the kind of 'virtual organisations' or 'virtual teams' that are becoming more commonplace. Summarising Handy (1992) Sage and Cuppan outline the following five features of a federation of systems:

1) **Subsidiarity:** the most important feature, meaning power should belong to the lowest possible point within the federation of systems.
2) **Interdependence:** This encourages combining organisations and technologies when and where appropriate, but does not necessarily align with centralisation.
3) **There is a uniform and standardized way of doing business:** Agreements are needed between organisations on the basic rules of conduct, standardised measuring classifications and common traditions of communication.

4) **Separation of powers:** Management, monitoring and governance should be viewed as separate functions, as successful operation takes time and attention.
5) **Dual citizenship:** Each individual is a participant in the local development group and the overall FoS at large. As Sage and Cuppan argue, it "is the federated '*citizenship'* that requires emphasis if the benefits of subsidiarity and interdependence are to be acquired by sponsors and customers of a FOS engineering program" (Sage and Cuppan 2001: 330).

While there has been growth in the number and variety of studies into systems of systems the field remains dominated by the engineering disciplines and is primarily concerned with issues of compatibility surrounding new information and communication technologies. As Keating et al observe, the "state of the system of systems literature is a fragmented collection of seemingly disparate perspectives on the associated phenomena" (Keating et al. 2003: 36). It can also be said that much of the literature has largely relied on "ontological discussions or the drawing of analogies between complex systems or system of systems with natural systems" without moving towards the "creation of a rigorous and active academic discipline" (Heydari 2014: 101).

There is a recognition within the literature that actors need to confront integration not just between and within infrastructures (such as between energy, water and transport) but also the integration of "human, organizational, and technological issues in all facets of life cycle activities that are intended to result in the fielding and support of systems" (Sage and Cuppan 2001: 325). Keating et al (2003) describe the emerging challenge facing engineers as understanding "how to address problems associated with integration of multiple complex systems" (Keating et al. 2003: 36). However, while the *interdependence of* the constituent infrastructures is a key feature of their operation, direct *integration between* them is not necessarily the primary focus. While it is important that managers and planners recognise the significance of the wider whole, it may be that many networks can function optimally when only loosely coupled to each other (Rinaldi et al. 2001).

To consider integration within the system of systems approach, we must examine the organisational and governance factors that contextualise infrastructures. Organisational integration as described within the system of systems approach does not necessarily require a single organisation to govern all infrastructures under one roof – indeed, the organisational independence of component systems is a key factor. Instead, the approach requires a lead authority with the necessary powers and capacity to act in a strong coordinating role, utilising a systems approach for infrastructure planning and design and then contracting the technologies and services as needed to meet the envisioned requirements. Each infrastructure can be viewed as a collection of interdependent subsystems that are combined and interrelated in ways that contribute to the stability of the whole. While the infrastructures themselves may remain technologically interdependent, the governance arrangements and the management of their interfaces do not have to be. It is possible (and may be optimal) for a single overarching organisation to take an overall view of urban infrastructures, align their investment priorities and deployment timetables, but to retain a 'hands off' role in terms of day-to-day operational practices. Here, integration can operate at the *strategic planning and design* level of infrastructural governance with strong central organisations able to create partnerships between differing providers and offer visions for partners to strive towards (for example, through the creation of urban masterplan documents), while having the capacity to act and coerce when needed. An obvious example would be a state actor (such as local or central government) that can potentially force unwilling utilities to cooperate with other providers and consumers. The 'siloed'

nature of current infrastructures can be maintained, and associated problems can be overcome by creating working groups between utilities, state actors and consumer groups. It is the *capacity* for a central governing organisation to direct the actions of subordinate bodies that is important. Major changes to institutional frameworks are not necessary. The emphasis is on an approach in which "all technical teams interact with each other to develop a strategy whose overall outcome is more sustainable than the sum of optimal individual solutions" (Page, Grange and Kirkpatrick 2008: 1).

One practical example of how this could work is the Integrated Resource Management (IRM) model developed by the consultancy firm ARUP (Figure 2.2) which calls for infrastructure integration to be undertaken at the design phase with utilities offering their support and organising their activities in coordination with the overall masterplan. While it is important to draw up plans that include all of a city's critical infrastructures they can remain under various forms of public or private control and can even remain siloed and splintered in governance terms. What is important is that investment priorities and urban planning is integrated and aligned at the strategic level and that a strong central organisation has access to all relevant information. Examples of this include many municipalities in North America which are adopting what they describe as integrated approaches to water planning with increasing coordination between supply, sanitary wastewater disposal and storm water management. While the policies may be enacted by different departments or by different utilities they all work towards the same vision of what to achieve (ARUP 2013).

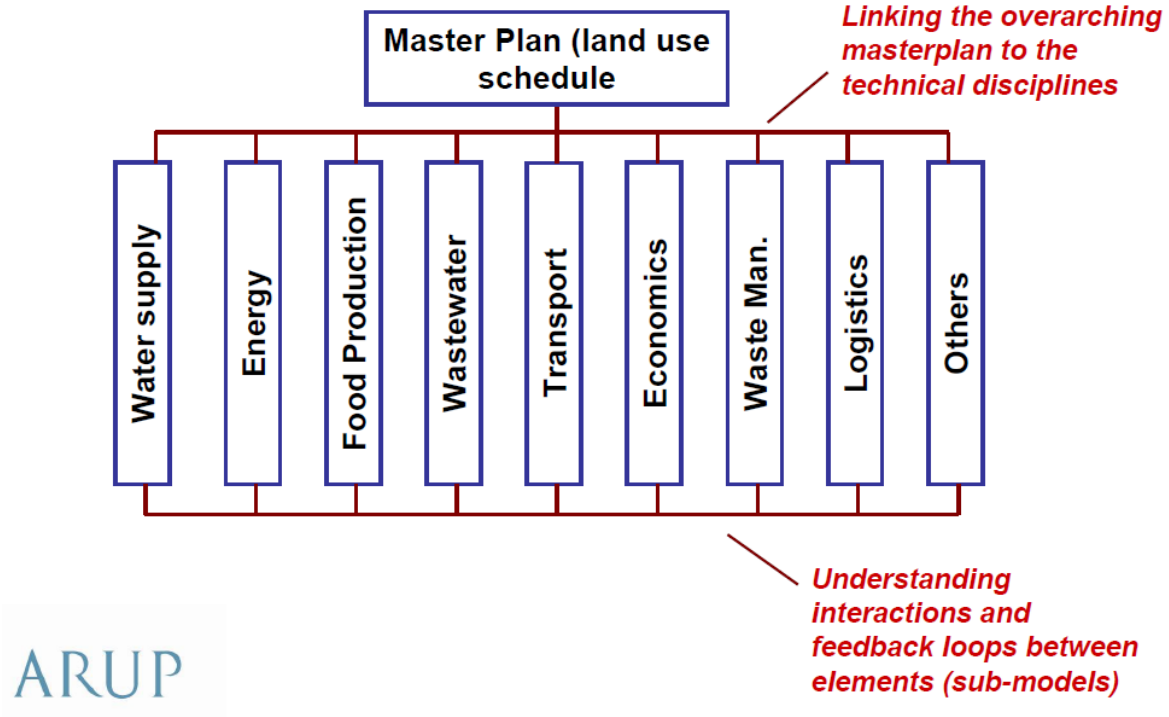


**FIGURE 2-2 THE INTEGRATED RESOURCE MANAGEMENT (IRM) MODEL (MASHFORD 2006)**

While academics are attempting to theorise the integration of various infrastructural sectors, at the same time there are several tools for city planners and officials in use to support policy-making and

urban planning. Common tools for energy include the MARKAL, MESSAGE and LEAP models; for food security and planning the Global Policy Dialogue Model (PODIUM); and for water the Water Evaluation and Planning (WEAP) system (Bazilian et al. 2011). The International Electrotechnical Commission outlines how modelling a city as a system of systems could work:

> "A promising approach to support city planners, but also standards developing organizations (SDOs), is to model a city as a collection of activity domains in an integrated virtual organization (the city), where various groups of stakeholders (local governments, public and private corporations, academia, healthcare institutions, cultural associations, religious congregations and financial firms) participate in operating and sustaining the city as a whole. Modelling the interrelations allows identifying pain points, gaps and overlaps in standardization and clarifying the technical needs for integration" (International Electrotechnical Commission 2015: 7).

However, the models often focus on just one system while ignoring or downplaying interdependencies with each other. They have also been criticised for "overly simplified spatial representations; are grand policy 'research' rather than short term applied 'policy'/decision support models, or analyse scenarios which are impractically long term" (Bazilian et al. 2011: 7901). The models also lack the capacity to explore political motivations behind certain decisions, the institutional structures that frame urban governance, and wider socio-economic and cultural issues inherent within cities. There are, however, several strands of academic research that specifically reference the potential (and even need) for organisational forms of integration. I will examine these in the next section.

#### 2.2.2.3 Organisational Forms of Integration

There is increasing recognition that integration may not occur without significant changes to the organisation, management and governance of infrastructure networks. The calls for increasing integration imply that existing practices of infrastructural management are not sufficient to achieve economic efficiencies or to facilitate sustainable urban environments. While the conceptualisation of integration inherent in the smart city discourse, for example, is dependent upon technological improvements and the deployment of decentralised technologies, it is also recognised that for integration to occur there needs to be significant changes to the regulatory environment surrounding these technologies alongside willing adoption by consumers. Infrastructure integration may require more than a simple back-office upgrade to existing systems, but instead would require a significant reconfiguration of socio-technical systems and their institutional environment.

Many studies cite the importance of organisational forms of infrastructure integration, whether through bringing together disparate organisations into a single unit or the creation of joint working groups that can meet to discuss infrastructural concerns. This could occur through changes to regulatory structures (such as through the centralisation of functions of the UK regulatory bodies Ofwat and Ofgem), through the creation of working groups between various organisations (that can plan and manage engineering works) or through shifts towards viewing homes as holistic consumers of resources and selling services such as heat and energy rather than individual units of electricity or

gas. There is an underlying assumption underpinning these calls that integration would inevitably lead to sustainability and resource efficiencies. As Moss et al argue (2009), forms of organisational integration are "generally interpreted to mean enrolling key representatives of the relevant agencies and actor groups and keeping the general public informed" (Moss et al. 2009: 20). Yet the difficulties associated with such forms of organisational integration may be difficult to overcome. For example, one criticism is that currently, planners and policy makers do not view their cities as a system of systems. Instead, projects proceed piecemeal whenever funding becomes available and some areas have little involvement with actors in other domains. As Hansmen et all recognise:

> "Our communities need to develop [a] fundamental understanding of the planning, design, and management of national infrastructure systems, such as those providing electric power, transport and communications. Although our academic and industrial organizations have great expertise in system components (such as power plants, aircraft or networks) we lack experience in the design of the 'systems of systems' that constitute our infrastructure at the total societal level. We do not have really solid understandings of how their technical, political and economic factors interact, particularly in the context of great uncertainties" (Hansman et al. 2006: 2).

Zerjav (2015) has identified the often "temporary and fluid nature of organisational boundaries that occur on complex projects" making it difficult to create truly integrated organisations, and suggests that the boundaries many proponents of integration seek to abolish are in fact a "structural feature of project organisations, rather than as a phenomenon that emerges through practices and their post-hoc interpretations" (Zerjav 2015: 1770). There is also an underlying "assumption that the actors involved can be readily identified and ascribed particular tasks of policy delivery based on their clearly defined roles" (Moss et al. 2009: 20). In reality, creating a coordinated management or governance structure for the various infrastructure sectors may be very difficult (Stead 2008). The system of systems approach however, does recognise the problems that emerge with various forms of organisational integration – indeed, one of the main tenets of a system of systems is organisational independence of the constituent networks, and recognition that it is the interfaces between infrastructures that are important. This is a call for coordination in the management of those interfaces rather than fully integrated governance models.

Stead (2008), in examining forms of policy integration, argues there is a hierarchy of types of integration that occur horizontally within the various departments in governments and between separate organisations (Figure 2.3). While his focus is on the integration of policy and planning, this conceptualisation is useful when examining forms of infrastructure integration:

- At the lowest level, integration could imply cooperation between and within organisations, creating a level of dialogue and information sharing that can improve governance.
- Next, there could be coordination, coherence and policy consistency, which could lead to cooperation, transparency and an attempt to avoid policy conflicts.
- Finally, a form of integration (joined-up policy), which includes the previous categories "but also includes joint working, attempts to create synergies between policies (win–win situations) and the use of the same goals to formulate policy" (Stead 2008: 140).

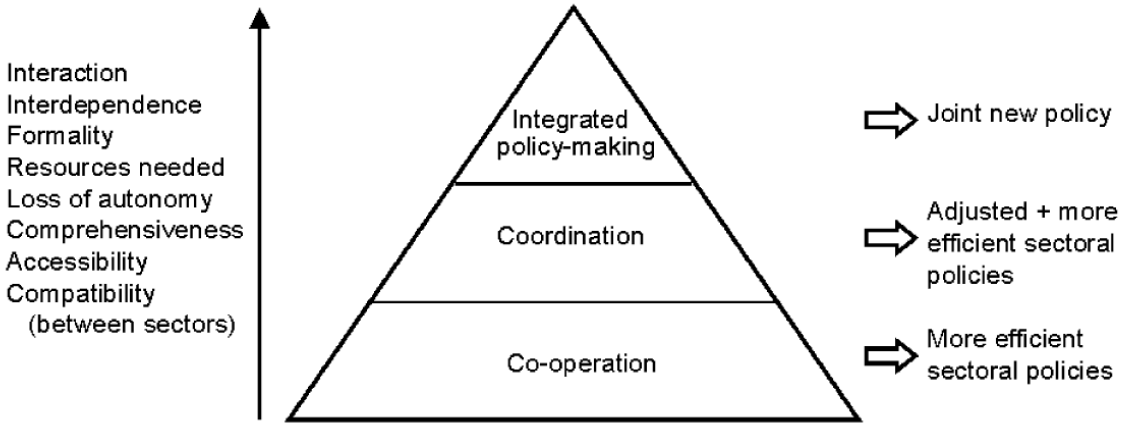


**FIGURE 2-3 INTEGRATED POLICY-MAKING, POLICY COORDINATION AND COOPERATION (STEAD 2008: 141)**

While this conceptualisation is useful, there remains an underlying assumption that more integration equals more efficiency and better outcomes, with little evidence (at least from infrastructural studies) that this would actually be the case. Indeed, while forms of organisational integration may be beneficial, they may not necessarily lead to a utopian ideal. Perrow (1984) argues that "neither better organization nor technological innovations appear to make them any less prone to system accidents" (Perrow 1984: 5). The fixes normally used to deal with the potential for large scale accidents can often increase the complexity of systems and can make networks "more prone to certain kinds of accidents" (Perrow 1984: 5).

One body of work that does attempt to address the organisational and governance concerns inherent within moves towards infrastructure integration is the research surrounding Multi-Utility Services Companies (MUSCos). While many countries and cities currently organise their infrastructures on a sectoral basis – one utility that manages electricity, one for gas, one for water – it is possible to create joint organisations, structures, or management networks that can govern multiple infrastructures simultaneously. A MUSCo has been offered as one variant of this, as "an entity which delivers services to end-users, as opposed to electricity, gas, petrol or water" (Roelich et al. 2015: 41). This may require a shift in provision away from selling 'products' and towards selling 'services': rather than the utility profiting from selling units of energy or water, it instead provides services such as illumination or thermal comfort, enabling utilities to profit by saving resources or by "providing the highest level of service at the lowest level of resource used" (Roelich et al. 2015: 42). These arrangements could see an integrated single organisation managing the entirety of a city's infrastructure. One advantage is the synergies offered by combining the management of different infrastructures – the skills involved in creating and maintaining underground network corridors are largely the same whether workers are laying energy cables, water pipes or sewage networks.

While the concept of a MUSCo offers a radical way to provide infrastructural services, there are difficulties in shifting from the current governance and operations arrangements towards one that would facilitate MUSCo ownership models. The ambitious concept calls for a transition to an entirely new infrastructure configuration which would be difficult due to "a number of barriers including lack of trust and experience, lock-in to mainstream technologies and operation modes, high transaction

costs associated with creating and monitoring contracts and the fragmented and entrenched regulatory and policy framework" (Roelich et al. 2015: 49). While it may appear appealing, this type of integrated provision would require a paradigmatic shift in current thinking. For utilities to be able to integrate in this way there would need to be shifts towards integration at the regulatory and governance level, for example by combining the functions of Ofgem (the United Kingdom's regulator for gas and electricity markets) with Ofwat (the regulator for the water industry). Does the UK government have the will or the capacity to make changes on this scale? It may be that these sorts of issues go beyond what is possible at an urban level. Importantly, the researchers also recognise that "end-user attitudes, beliefs, habits or routines, personal capabilities, and contextual factors have been identified as barriers to the adoption of cost-effective technologies in studies across different infrastructure streams" (Roelich et al. 2015: 42).

### 2.2.3 Summary

In summary, the literature reviewed in this section demonstrates the multifaceted and potentially infinite variety of ways in which infrastructure integration may occur, however the studies do have flaws. Critical perspectives on infrastructure integration are "virtually non-existent" within the academic literature: the processes, technologies, scales and contested relationships that exist that may facilitate or constrain forms of integration policies have been overlooked within scholarship, and there is a "striking absence of theoretically informed spatial and political analysis" on what infrastructure integration might entail (Williams et al. 2014: 4). The concept is often taken for granted as a beneficial aim to aspire towards, but it is rarely problematized as something that should be defined. Questions regarding what political or economic processes it would necessitate or facilitate are never asked, and any beneficial aspects of the current 'splintered' networks are never addressed. Indeed, infrastructure integration is a concept that is "never complete" and can either "inspire dread or the offer of untapped potential" (Workman, Mendes and Thomas 2014: 17).

So far in this chapter, I have outlined the three features important to infrastructure research, and have reviewed the literature covering the potential for infrastructure 'integration'. In the next section I seek to build on this literature review by drawing out the key issues raised and creating a conceptual framework that can underpin the rest of this thesis.

## 2.3 Situating Urban Infrastructure Integration: A Conceptual Framework

One challenge for researchers when conducting literature reviews is not to merely "summarize what they find, but to synthesize it in a way that develops new theory beyond the mere sum of the collated studies" (Okoli 2015: 2). In this section I seek to do just that. I begin by drawing out the important features uncovered in the literature review in Section 2.2, arguing that there are three commonalities within studies that can help frame our conceptualisation of infrastructure integration: One, that integration is almost universally viewed as a beneficial concept; two, that it

can occur at a variety of scales, and three, that it can take a variety of forms. Following this, I use these three commonalities to create a working conceptualisation of the term 'infrastructure integration'. Finally, the main points drawn from Sections 2.1 and 2.2 are used to create a conceptual framework which will be used to situate the forms of infrastructure integration that emerge in the empirical case study chapters. I begin this section with an attempt to define the concept of 'infrastructure integration'.

### 2.3.1 Defining Infrastructure Integration

There are several common features that can be drawn from the academic literature reviewed in Section 2.2 that can help frame our conceptualisation of infrastructure integration. First, is the often uncritical view that integration is beneficial, second is the various scales it can operate at, and third is the various forms it can take.

First, much of the academic literature takes an uncritical view of infrastructure integration and almost all studies identify it as a positive concept to be achieved – it is viewed as an aspiration that should be worked towards to achieve sustainable cities and as a way to create efficiencies and achieve economies of scale. Existing infrastructural governance frameworks and organisational structures – especially if they are governed in 'splintered' sectors – are often viewed as obstacles to be overcome, as problems to be solved and adapted in such ways that would allow for further integration, whatever this nebulous concept may mean. Little thought is given to the idea that the splintered networks are 'splintered' precisely because this may be the most efficient, economic or sustainable form of infrastructural governance. Instead, integration is viewed as a panacea and its benefits are rarely challenged within the literature. One example of this uncritical appraisal of integration can be seen from the International Electrotechnical Commission, which argues: "technology integration helps cities to improve efficiency, enhance their economic potential, reduce costs, open the door to new business and services, and improve the living conditions of its citizens" (International Electrotechnical Commission 2015: 6).

Yet, if infrastructure integration is almost universally praised, why is it not already being actively pursued as a policy? Clearly, there are barriers that can constrain and shape what form of integration is possible, the extent to which it can be achieved, and for whom it may benefit. Large infrastructure networks are highly complex and necessitate the involvement of a multitude of actors, end users and organisations in their creation and management. In many cases these systems "require organizational structures that have large internal contradictions" creating a level of complexity that is often difficult to manage (Perrow 1984: 2). In some cases, the lack of institutional capacity to handle this complexity is preventing forms of infrastructure integration from occurring. The European Environment Agency, for example, argues:

> "Many obstacles to the development of integrated urban policies can be identified, such as the fragmentation of institutions and thereby the fragmentation of responsibilities (e.g. separate budgets, timelines and goals), the excessive specialisation and overwhelming complexity (e.g. 'silo thinking', incomplete perspectives on urban resource use and the associated costs), single-

purpose solutions that fail to address the urban system as a whole, and short-term and narrow accounting formats (e.g. some important elements are not systematically taken into account such as indirect costs and benefits, maintenance costs, replacement costs, all capital assets – ecological, social, economic) (EEA 2015b: 11)."

Williams et al (2014) argue that the consensus in integration studies (the authors have a particular emphasis on the water and energy nexus) is that integrated management will inevitably lead to more sustainable management practices, and that "fundamentally, this is a call for purely efficiency-based solutions to tensions and trade-offs between energy and water, and one that is entirely consistent with market-based approaches to environmental governance" (Williams et al. 2014: 5). They add:

"The concept of 'integration' has become a panacea for the negative aspects of the nexus, an ultimate solution that forestalls more politically informed discussions. This assumed logic ultimately implies that the serious challenges posed by the nexus framework, do not in fact require real political change" (Williams et al. 2014: 5).

The power relations inherent within infrastructural management, issues surrounding actors' motivations and an organisation's capacity to act are often overlooked by integration proponents. While models such as ARUP's Integrated Resource Model and the system of systems approach are useful tools in analysing how various infrastructures may work together and how interdependencies can be managed, there is little motivation within these models to go beyond what can often be quite technical solutions. What happens in a situation where actors simply do not want integration to occur? While researchers examining MUSCos do recognise that "end-user attitudes, beliefs, habits or routines, personal capabilities, and contextual factors" can be barriers to successful integration policies (Roelich et al. 2015: 42), just how these factors can be brought into analytical studies is not discussed.

The second feature of infrastructure integration that emerges from the literature is an emphasis on the wide variety of scales it could operate at, yet much of the literature remains non-committal on the optimal scale at which integration should occur. Should it occur at the local level within the home, with a focus on the integration of infrastructure delivery streams? Or would national or international forms of integration be more beneficial and provide benefits on a wider scale? The European Environment Agency suggests to be truly effective, projects to tackle resource efficiency and sustainability need to operate on "many levels and among many stakeholder groups, cutting across sectoral and functional specialisation and jurisdictional boundaries" (EEA 2015a: 11). The energy system, for example, operates at numerous scales – offshore wind farms and small decentralised renewable energy projects need to be plugged into local distribution networks which are themselves part of a larger electricity market that can be governed by national (and increasingly international) regulatory agencies (Goldthau 2014). There are tensions between the large technical systems that have supplied services to cities since the late 19$^{th}$ Century and innovations that provide opportunities for decentralisation and small-scale, community-based networks. One major problem with the growth of renewable energy is how to integrate these small-scale developments into the existing larger grid. Galperin and Bar (2006) highlight the growing potential for small community-based organisations to provide telecommunication services to the rural poor who are often overlooked by traditional large telecommunication providers. While there is little evidence to

suggest small-scale decentralised technologies will replace existing centralised networks, Leach et al (2015) suggest that of necessity there will be a hybrid mix of small and large-scale infrastructures: but integrating the differing scales remains a problem.

Smaller scale developments, such as individual buildings or even district-level improvements or transformations, may not be radical enough to provide the benefits often cited by backers of infrastructure integration. These developments, such as eco homes or low carbon projects, can often be piecemeal and occur without widespread changes to the existing institutional environment. These forms of small-scale integration are "much more concerned with the integration at the scale of the development than with the wider transformation of the existing city of its incumbent infrastructure network" (Hodson and Marvin 2010b: 66). Yet even these small developments may face problems in terms of integration; for example, in administering the multitude of contracts between the various splintered infrastructure providers. While the majority of resource consumption does take place at the scale of the building unit and technology can be easily changed or replaced, a single building is not the most optimal scale for energy efficiency, water conservation or renewable energy (EEA 2015b): instead, neighbourhoods and districts may yield more returns in integration projects. However, the complexity of projects increases with the spatial scale and there are growing complexities involved with incorporating a wider variety of stakeholders in discussions.

At the larger scale, large infrastructure projects can often fail to take into account linkages between the large and small scales, overlooking opportunities for integrating the various levels and creating conflicts between stakeholders (Arts et al. 2016). While discussions and decisions taken at the strategic level can often be well integrated, once this filters down to the local operational scale it can often become focused on implementation only, overlooking the potential for local input (Niekerk and Arts 1996). While research has suggested that the integration of regional spatial plans can result in improving the day-to-day processes of planning and policy making, little evidence is provided that the integration enacted so far has actually improved final outputs (Olagunju and Gunn 2016).

The third feature of infrastructure integration that emerges from the academic literature is an emphasis on the variety of forms it may take. One key rationale of this thesis is a recognition that the concept of infrastructure integration is diffuse, difficult to define, contested, and 'messy'. This is reflected in much of the literature which rarely attempts to pin down what forms of integration are being proposed. This may make it difficult for policy makers or planners to enact policies that can facilitate specific forms of infrastructure integration. The European Innovation Partnership on Smart Cities and Communities, for example, calls for both "new joined-up approaches" in infrastructural governance and "the exploitation of modern technologies", seemingly calling for both organisational and technological forms of integration to occur simultaneously (EIP-SCC Undated: para 1). Just how this could be achieved is not discussed. Researchers studying the possibility to implement MUSCos argue that a variety of forms of integration are needed, such as 'organisational' through the creation of single, overarching organisations that are able to manage the entirety of an area's infrastructure, and technological through changes to infrastructural delivery systems within homes and neighbourhoods. By necessity, a shift towards a MUSCo will also involve forms of integration within national governments, such as through regulatory changes to combine the responsibilities of Ofgem, Ofwat and Ofcom. Much of the literature on smart cities, meanwhile, emphasises the need for 'technological' forms of integration, driven by innovations to create efficiencies and improve urban

infrastructural 'flows'. Similar calls are made within the nexus literature with calls to improve system wide efficiencies.

What is clear from the academic literature is that there is no 'one size fits all' approach to infrastructure integration. Once we begin to examine what integration may entail, it becomes apparent that the form it may take is dependent upon the specifics of the socio-technical system under study, the surrounding institutional context which can frame what options are possible, and the nature of the context-specific organisational and institutional structure. There are a multitude of forms of integration that may occur, and there a wide variety of options for urban areas to explore.

Based on the discussion of the literature so far, we can develop a working conceptualisation of what 'infrastructure integration' may actually mean. This definition can be regarded as an initial 'hunch' for the purposes of this project and is used to guide analysis and questioning of the data (Cowley et al. 2000). For the purposes of this thesis a working definition of 'infrastructure integration' is:

> *The bringing together of technologies, actors or organisational structures (whether through changes in governance, operational practices or forms of service provision) at a variety of scales and forms that can lead to more sustainable, economic and resource-efficient infrastructure networks.*

This definition relies on the three commonalities drawn from the literature review above: that there is an accepted belief that integration is a beneficial concept and something that should be pursued in and of itself; that integration can (and often must) occur at a variety of scales; and that there are a variety of forms it may take, recognising that while technologies or engineering standards are important, policies must also address how the organisation and management of infrastructures can influence the aims and methods of how infrastructures can be integrated. This initial definition is useful when examining what forms of infrastructure integration are present in the three case study cities.

### 2.3.2 Situating Infrastructure Integration

The definition developed above has been used to create a conceptual framework in which the forms of integration drawn from the empirical data can be situated. Yin (1994) suggests that, while a wide variety of theories and frameworks are utilised in research, it is useful to start with a small but clearly formulated framework which can be adapted throughout the case study analysis. As Maxwell (2013) argues, a conceptual framework is:

> "…primarily a conception or model of what is out there that you plan to study, and of what is going on with these things and why – a tentative *theory* of the phenomena that you are investigating. The function of this theory is to inform the rest of your design – to help you to assess and refine your goals, develop realistic and relevant research questions, select appropriate methods, and identify potential validity threats to your conclusions" (Maxwell 2013: 39).

The framework will explain “graphically or in narrative form, the main things to be studied—the key factors, concepts, or variables – and the presumed relationships among them” (Maxwell 2013: 18). The conceptual framework developed for this thesis is graphically represented in Figure 2.4.

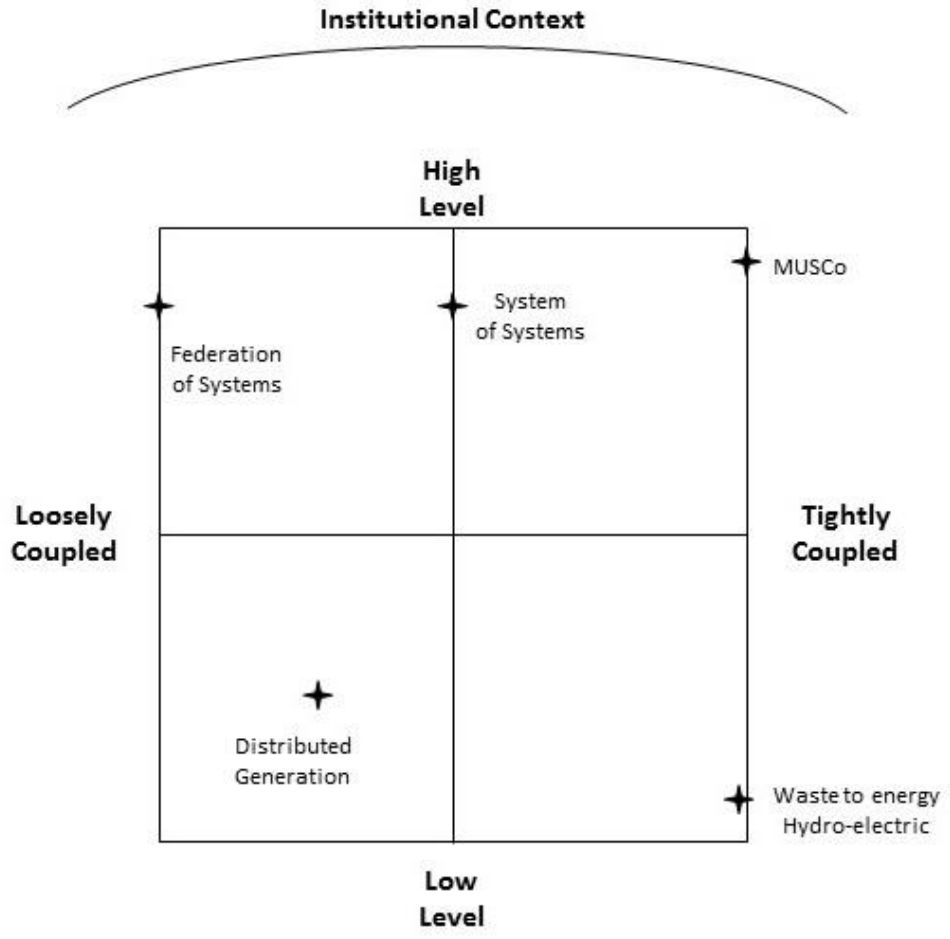


**FIGURE 2-4 AN INFRASTRUCTURE INTEGRATION CONCEPTUAL FRAMEWORK**

The framework incorporates the key issues that have emerged during the literature review. First, the processes of infrastructure integration and infrastructure unbundling occur in actually existing places, in cities that have their own institutional environment with a particular culture, socio-political economy and specific ‘rules of the game’. This institutional context structures (but does not necessarily determine) the extent of infrastructure integration. While the focus of this thesis is on the urban scale of infrastructure integration, these urban areas exist within particular institutional environments which can vary from one city to the next. The institutional context of the three case study cities will be fully examined in Chapter 4.

Second, infrastructure integration may occur at a variety of scales, represented on the vertical axis of the framework. High level forms of integration could include integration occurring at the strategic level of governance networks: within and between governmental departments or regulatory bodies at a national level or through cities taking a strategic holistic view of all their infrastructures, as

envisioned through ARUP's IRM model and the system of systems approach. Integration occurring at a high level could involve changes to the governance, management and organisation of infrastructures. At the middle level, integration could involve operational concerns that arise out of the day-to-day activities of actors in organisations tasked with infrastructural management, pursuing forms of integration if it appears to be a clear way to improve working practices. This can involve activities that are so routinized that the actors involved do not necessarily realise they are engaged in processes of integration. These actions can often evolve without input from management or even without the active knowledge of those involved. One example could be the project management and coordination needed between infrastructure providers and city officials when undertaking street works in urban centres, or in the collaboration between telecommunication providers sharing mobile phone masts. Low level forms of integration, meanwhile, can refer to integration at the end points of complex supply chains, integrating infrastructures within the home (which can occur without forms of integration occurring at higher scales) or in changing how consumers interact with infrastructural access points (such as through shared billing services). It should be noted that the scale axis can incorporate geographic scales (national, regional and local) or forms of technological integration (small scale decentralised generation or large scale national electricity grid reinforcement).

Third, the horizontal axis of Figure 2.4 refers to the varying degrees of 'coupling' that infrastructure integration may involve, allowing us to accommodate the various forms that may exist within the case study cities. This is represented by 'tightly coupled' at one extreme and 'loosely coupled' at the other. Perrow (1984), in discussing how cascading incidents can cause multiple systems to fail, argues that infrastructures are tightly coupled to each other when their successful operation is dependent upon the operation of a linked counterpart, and a change in one system can rapidly affect the state of the other. One example can be a hydro-electric plant (with electricity generation dependent upon the successful delivery of water) or a waste-to-energy plant (with electricity generation dependent upon the successful delivery of waste). Loosely coupled infrastructures, although not fully integrated, remain linked with each other in some form, yet their successful operation is not so dependent upon their linked counterpoint: a federation of systems can operate in this way.

In many cases it may be that increasing the degree of coupling between infrastructures could lead to an increase in the scale at which integration occurs, or at least an increase in the level of control or oversight needed for successful operation. If this is the case, increasing the integration of any feature could see it move towards the top right of the framework. One example is the growth of distributed generation within the electricity system: integrating small decentralised plants into the wider grid needs greater oversight and standards control by planners, such as through the correct management of voltage transfer arrangements and through accommodating and managing two-way flows of energy. As such, integrating the technological components would see an increase in the scale at which management occurs. However, while the scale of integration and the degree of its coupling may appear interdependent, this is not always the case. For example, waste-to-energy plants and hydro-electric plants do not need high-level forms of organisational or strategic integration to operate. Instead, they are integrated at the interfaces between two disparate networks and essentially function at the end points of two complex supply chains. They are tightly coupled (a failure in one network would lead to cascading impacts in supply), however they can operate independently of wider organisational processes. There is no need for a MUSCo-type

organisation to oversee them, and small-scale private operators could remain viable regardless of wider changes to the networks.

This framework will be used to situate the forms of infrastructure integration that are found in the empirical case study cities in Chapters 5, 6, and 7.

## 2.4 CONCLUSION

This chapter has sought to examine the key concepts that underline this thesis and to create a conceptual framework that can be used to situate the various forms of infrastructure integration found within the three case study cities. I began this chapter with an exploration of the three features key to infrastructure research: First, infrastructures should be viewed as socio-technical systems that are shaped by society and are society shaping; second, these socio-technical systems are embedded within their institutional environments which can shape the creation of new networks, the management of existing systems, and the range of options on offer to those involved in infrastructure governance; and third, it is at the urban scale that infrastructure interventions may have the largest impact. By viewing infrastructures in this way, it is possible to investigate the social, political and organisational aspects of infrastructure provision within the three case study cities, going beyond a simple examination of the physical components of networks and their geographical environments. This PhD argues against a purely technological determinist view of infrastructures, in that it is not only technological innovations that are driving changes to networks, but rather a combination of evolving interlinked features such as macro-level shifts in the global economy, a growing recognition of climate change, and the context-specific views and behaviours of those involved within infrastructural management. To fully understand what is driving the integration of infrastructures, it must be noted that different cultures and different cities will have different problems to address and varying opportunities for action.

Following this, I conducted a review of the 'integration' literature, arguing that there are three commonalities that can be drawn out: First, integration is often uncritically viewed as a positive aspiration that should be worked towards; second, it can occur at a variety of scales; and third, it can take a variety of forms. These commonalities have been used to create a working definition of 'infrastructure integration' (discussed in Section 2.3.1), and have informed the creation of the conceptual framework outlined in Figure 2.4. This framework recognises that socio-technical systems are embedded within their institutional environment. It allows for an exploration of the various scales in which it may occur, and it allows us to situate the multitude of forms of integration into a single, overarching framework. I will return to this framework in each of the empirical case study cities in order to situate the forms of 'actually existing' integration that have emerged during the fieldwork.

In the next chapter I explain the methodology of this thesis. I will outline the research questions, discuss the suitability of using qualitative research for this project, discuss the selection of the three case study cities, and outline how the research was conducted.

# 3 METHODOLOGY

This chapter seeks to outline the methodological approach that I chose to adopt for the research, and it seeks to answer questions relating to how we can research the concept of infrastructure integration. In Chapter 2 I created a conceptual framework which will be used to situate the forms of infrastructure integration that emerge in the three case study cities. In this chapter, it is important to examine how can we research socio-technical systems, how can we identify the forms of infrastructure integration that emerge during the data collection process, and how can we identify the factors that influence it, prevent it or facilitate it. I argue that the most suitable method is through a qualitative research approach, undertaking semi-structured interviews and documentary analysis in three case study cities. This will allow for a degree of depth (allowing for a significant amount of time to be spent studying each city) and breadth (with three cities allowing for analytical generalisations to be made) in the research process.

This chapter starts by an examination of how we can research socio-technical systems. I argue that the issues surrounding infrastructure integration can only be examined by looking at the governance and institutional structures of multiple infrastructures, rather than conducting an analysis of a single infrastructure, which is common in much academic research. Following this, I reiterate the aim and objectives of the project and seek to develop the research questions that will guide the research in the coming chapters. Next, I explore the qualitative research approach that will be utilised and outline why a comparative case study focus is suitable. Next, the chapter discusses the rationale for choosing Seattle, Munich and Sheffield as case study cities, and the chapter finishes with a detailed description of the field research process, the interview techniques adopted, and the coding methods that were used to analyse the resulting material.

## 3.1 RESEARCHING SOCIO-TECHNICAL SYSTEMS

In this section I seek to discuss the decisions taken in relation to the methodology adopted by this project. I begin with an examination of how we can research socio-technical systems, outline the setting of the research questions, and then justify the use of qualitative research. This section begins with an examination as to why it is suitable to study the governance of multiple infrastructure sectors within a single research project.

Monstadt (2009) has argued that while recent social science research has offered important insights into infrastructural studies the majority of studies are often sector-specific and lacking in cross-cutting approaches that look beyond individual networks to examine interdependences and urban interactions (Monstadt 2009). One problem is the lack of knowledge and experience social science academics have in the design and management of 'systems of systems' that make up infrastructures at the societal level, with little "solid understandings of how their technical, political and economic factors interact, particularly in the context of great uncertainties" (Hansman et al. 2006: 2). Hansman et al highlight the importance of conducting a comparative analysis across infrastructure domains with a goal to "expand the understanding of the fundamental issues that drive infrastructure

operation and evolution" (Hansman et al. 2006: 4). The tendency of many academics is to concentrate on specific technologies or within specific sectors at the expense of integrating knowledge between disciplines. One reason for the limited attention to the integration of infrastructures is that it can be challenging to work across different infrastructure domains at different scales investigating what might be a fairly abstract idea. By carrying out a cross-sectoral study of more than one infrastructure this research project has "tremendous potential to increase understanding and offer new insights on the technological, economic, regulatory, institutional, and systemic aspects of each infrastructure domain" (Hansman et al. 2006: 4). Because of this it was felt at an early stage not to narrow the scope of the research by focusing on individual sectors such as energy or water, as important as these are. Instead it was decided to investigate the management of all a city's hard infrastructures: energy, water, waste, transport and telecommunications.

There are two important points with regards to this. First, is the central hypothesis that "infrastructure systems share patterns that can be exploited for learning and innovation" (Hansman et al. 2006: 6). While water, energy, transport, waste and telecommunications may seem to have little in common they do face similar problems such as congestion and the increasing costs of renewal and, as such, the governance of these infrastructures may face similar opportunities and challenges. Second, is the realisation that many of the challenges faced by those involved within infrastructural management are not only technical but also social, political and economic, and are associated with "the difficulties in reaching a common understanding of need, approach, costs and expectations among the decision makers and other stakeholders involved with the development of a specific system" (Hansman et al. 2006: 10). In Chapter 2 infrastructures are defined as socio-technical systems, with the recognition that studies need to go beyond purely engineering solutions to contemporary problems. As such, it is important to examine not just how various technologies can 'integrate' with each other, but also to ask where the promotion of integration is coming from, if indeed actors involved within governance frameworks believe it should be an agenda to be followed? How is integration interpreted and what impact does this interpretation have? Do cities have the ability to pursue infrastructure integration if they desire? Infrastructural networks necessitate complex interactions between a multitude of actors and organisations creating conflicts and contestations between users, producers and third parties. The 'conflictual dimension' of these networks must be recognised, as "conflicts are the rule, not the exception" (Coutard 1999: 13). Studies need to examine the actors involved in the day-to-day management of large technical networks and attempt to research the motivations of engineers, policy makers and urban planners in order to reveal the motivations behind decisions taken in relation to how infrastructures are managed, to understand what institutional structures actors operate within, and to assess what options are available to those who believe infrastructure integration to be something to be pursued. My aim for the empirical chapters is to explore the motivations and conflicts inherent within infrastructural governance within the three case study cities, to understand how these conflicts can impact upon decision-making within infrastructural governance networks, and to investigate how this can allow or prevent forms of infrastructure integration.

To deal with these issues, a research approach is needed that can analyse the explicit and implicit issues of infrastructure integration, finding a way to uncover the tacit and potentially unconsidered dimensions of urban infrastructure integration. It was decided that to do this, a qualitative research method is appropriate. Before outlining why this particular approach was chosen however, it is important to discuss the creation of the research questions.

### 3.1.1 Setting the Research Questions

The first aim in any research project is to define the phenomenon that is to be studied. As outlined in the introductory chapter, the aim of this thesis is to examine the evolving context and the potential of urban infrastructure integration. The project has four overarching objectives:

1) To develop a conceptual framework for researching urban infrastructure integration.
2) To examine perceptions of the rationale, opportunities and potential constraints for enhanced urban infrastructure integration in the three case study cities.
3) To investigate examples of effective urban infrastructure integration in the three case study cities, to understand what can facilitate integration and what can constrain it.
4) To contribute to wider conceptual discussions about the ideas and definitions of infrastructure integration.

In Chapter 2 I conducted a review of the literature covering the integration of infrastructures, concluding that there are three key features that emerge that can aid us in a broad definition of integration as a concept: it is seen as something beneficial, it can occur at a variety of scales, and it can take a variety of forms. Following this, the next issue is the nature of the research questions. Easton argues that, using critical realism, one question must be "What caused the events associated with the phenomenon to occur"? It is important to develop research questions that seek to address the main issues relating to infrastructure integration. These questions emerge from the need to view infrastructures as socio-technical systems that are embedded within their institutional context, the need to recognise that the 'integration' of these systems is a contested and messy process, and there are differences between the theory of integrating infrastructures and the actually existing reality of integration. With this in mind the study will seek to answer four research questions that each seeks to address a key issue associated with infrastructure integration: its meanings, its context, its practices and its impacts.

1) ***What is meant by the term integrated infrastructure?*** As already highlighted, the term itself is open to interpretation and can be described as a 'chaotic concept'. What does the term mean? Is integration between the various utilities important? Or should the main focus be on integration within particular infrastructures? Only by examining what is meant by the concept will the project be able to examine the barriers and opportunities in detail.
2) ***What are the capacities, opportunities or barriers for integration?*** By examining a city of 'best practice' I aim to examine what conditions allow for integration to take place. By researching an idealised city with structures that are (supposedly) already in place to facilitate integration, then if integration can take place, it will take place here. The project will explore what these conditions are and whether they are context-dependent or available for use in other cities. Just who decides if integration should be pursued, what drives their decision-making, how is that decision-making made and where does the knowledge come

from? There is a clear difference in pushing for integration to cut economic costs and to reduce climate emissions.

3) ***What is and is not being integrated in practice?*** By using a case study approach and looking at different aspects of infrastructure provision in different urban areas I aim to examine what forms of infrastructure integration are currently happening in practice. Because of the ambiguous and nebulous nature of the term 'integrated infrastructure' it is difficult to identify researchers or engineers who would disagree with the idea that integration is beneficial. Yet is it practical for all infrastructures to be integrated in such a way that they are all managed by one organisation or institution? While there may be obvious benefits in partnership working between energy and transport managers (such as in shifting the charging of electric vehicles towards off-peak time periods) in practice this may not be possible. It is important to examine the actual practices underway to identify what networks and technologies can be integrated, what cannot, and at what scale.

4) ***What are the likely social, economic and political impacts of integrating urban infrastructures***? Infrastructure networks are not neutral objects but are continuously transforming and being transformed by society. Changes within the networks will have impacts on urban residents. For example, new technologies are enabling decentralised and micro-infrastructures to emerge, changing how residents interact with networks on a daily basis. By examining the social, economic and political implications of integration it may be possible to identify affected parties.

These research questions are intentionally general, in order to explore and capture the complexity of infrastructure integration and to allow for an open research process, one which does not become focused on the minutiae of the day-to-day operational management of socio-technical systems, but one which can expand and broaden depending on the empirical data collection process. Key is to allow the research participants to offer their own views on what infrastructure integration means and what it may entail, and to explore the meanings that interviewees have on the concept, rather than narrowing the process through adopting my own meanings and definitions.

Now that these research questions have been set, the next stage is to identify the best way to gather data on those issues. For this project, it was decided that qualitative research methods should be adopted.

### 3.1.2 Undertaking Qualitative Research

As outlined in the introductory chapter, this PhD relies on a critical realist ontology. Critical realism argues that, while there is a reality independent of human thought, the way actors perceive that reality depends on their beliefs, expectations, and knowledge which in turn shapes their actions (Gray 2013). As such, an absolute truth about the impacts of laws, regulations, institutional structures and cultures may be difficult, if not impossible, to identify. A fixed theoretical position taken at the outset of a research project underpinned by critical realism is unhelpful, however a tentative theory or conceptual framework can be useful to inform the study and guide the

researcher. Indeed, critical realism advocates for research to begin with a particular problem which has been guided by theory (Fletcher 2017), yet while existing theory can provide a starting point for empirical research, "existing theories may not necessarily reflect reality accurately, and some theories may be more correct than others" (Fletcher 2017: 184). As argued in Chapter 2, there is little research analysing what 'infrastructure integration' may actually involve: it is a concept that is difficult to define, can be contested, and may never have an actual end point.

Few studies have provided a detailed description of the research methods best suited to critical realism, with few published papers demonstrating how critical realism has informed data collection and analysis (Fletcher 2017: 182). Fletcher (2017) argues that data analysis under critical realism begins with the search for 'demi-regularities' at the empirical level of reality. Trying to predict what impact a specific variable may have on society is difficult, if not impossible, as the social world does not follow a causal law of x + y = z. While it is acknowledged that ideas, ideologies, politics and cultures can all influence socio-technical systems, concepts of cause and effect are difficult to identify. Instead, critical realism looks for tendencies, not laws (demi-regularities) which can be identified through qualitative data coding. One issue with the 'integration' of infrastructures is that it may depend on a number of features that may be difficult to identify or classify through quantitative methods – how can we quantify the knowledge actors have about their roles and their belief in their ability to enact change. Another issue is that existing forms of infrastructure integration may be so routinized that they are not considered as 'integration', while those who make infrastructure management choices might not think automatically of integration possibilities. Okoli argues that critical realists "recognize that the open systems of social phenomena require qualitative empirical evidence to accurately identify and explain the structural mechanisms that generate social phenomena" (Okoli 2015: 17). This thesis needs a set of research methods that can "tease out and disentangle" a complex set of relationships, institutional arrangements and causal factors (Easton 2010). As such, it was felt that qualitative research methods should be utilised.

While critical realism does not reject the use of quantitative research methods such as statistics or numerical modelling, critical realist researchers believe that it is important to "examine deeper causal processes at work in the world" (Roberts 2014: 7). As such, "qualitative methods assist the researcher to undertake this task by helping him or her construct a model of a potential mechanism through analogies to other known objects, which will then be used to explain a set of observable patterns" (Roberts 2014: 6). The conceptual framework developed in Section 2.3 consists of such a model – infrastructures (viewed as socio-technical systems) can be tightly or loosely coupled to each other, and integration possibilities can oprate on a 'high' (e.g. strategic) level or a 'low' (e.g. operational) level. This will allow for us to situate the forms of infrastructure integration that emerges from the case study cities into a single model, and allow the empirical data to be placed on a comparable footing. Qualitative research used in this way can "delve into under-exposed and thus under-theorized phenomena" (Baxter 2000: 89). It can offer valuable insights and opens the possibility for the investigation of larger, potentially global, phenomena (Hesse-Biber and Leavy 2006).

Now that qualitative research has been chosen as a suitable set of methods, we can begin to examine how to conduct qualitative research. The key method chosen for this thesis is the use of documentary analysis and 'elite' interviewing through the use of case study research.

### 3.1.3 CASE STUDY RESEARCH

A case study approach to this research allows for the examination of the institutions and organisations involved in infrastructural management, to identify why certain decisions are taken, where the required knowledge comes from, and to explore wider social and political implications of increasing infrastructure integration within relatively contained urban areas. It can help uncover actor perceptions of the strengths and limitations of existing forms of infrastructure provision and management and uncover any possibilities for change. It allows for an understanding of the historical background and physical context of many projects underway in urban areas, offering the best way to "refine general theory and apply effective interventions in complex situations" (Stoecker 1991: 109). Baxter defines case study research as involving "the study of a single instance or small number of instances of a phenomenon in order to explore in-depth nuances of the phenomenon and the contextual influences on and explanations of that phenomenon" (Baxter 2000: 81).

One criticism of the case study approach is that it can often generate common-sense results that need follow-up research to provide verification or replication (Campbell 1961). A second is that it is often a study of a foreign setting by an outsider which is often based on anecdotal, single-case observations that can draw obvious conclusions (Xiao and Smith 2006). Qualitative case study research often involves the investigation of social and political situations leading to claims it can be intuitive, primitive, unmanageable, and less well formulated than 'hard' physical scientific research (Miles 1979). Yet despite these limitations (and misconceptions) qualitative case study research can provide valuable insights into the varying conceptions of infrastructure integration. The "advantage of the case-study method is that it helps to reveal the importance of contingency, and shows tensions that exist within the complex workings of institutions and actors" (Tretter 2013: 2). Yin found the use of the approach has been high and increasing over the years (Yin 2003) and is frequently found in "anthropology, psychology, sociology, political science, social work, business/marketing, organizational research, community studies, innovation and technological changes, life histories of individual or families, industrial relations, education, law enforcement, public health, planning and development, and even program evaluation" (Xiao and Smith 2006: 739). Case studies allow researchers to gain a holistic understanding of issues and can examine problems from different angles and dimensions, providing valuable data on solving problems in 'real life' situations (Yin 2003) as well as providing depth in research, as opposed to the breadth standard in many quantitative methods. The case study approach allows for the analysis of contemporary phenomena within the real world "especially when the boundaries between the phenomenon and context are not clearly evident" (Yin 2003). As highlighted in the literature review this is clearly the case for socio-technical systems. As Flyvbjerg writes "the case study is a necessary and sufficient method for certain important research tasks in the social sciences, and it is a method that holds up well when compared to other methods in the gamut of social science research methodology" (Flyvbjerg 2006: 241). It also offers the best way to "refine general theory and apply effective interventions in complex situations" (Stoecker 1991: 109).

To allow for an adequate level of 'analytical generalisation', this thesis will examine three case study cities. One of the main advantages of comparative case study research is that it can allow for an "examination of patterns of similarities and differences across a moderate number of cases, thus

combining depth with a more extensive approach" (Bergene 2007: 7). The idea of 'analytical generalisation' necessitates the creation of a conceptual framework that can be used as a template to compare and contrast the empirical results of the case studies (Cowley et al. 2000). This framework was developed in Section 2.3. The case studies chosen for this research are not individual sampling units to be used in a statistical sense. Instead, the findings from all three can be "generalised to that theoretical base according to the degree of support the findings provide to the original propositions" (Crosthwaite, MacLeod and Malcolm 1997: 204). This allows for the generalisation of the theory so it can be applied beyond the immediate case study findings.

The methodological approach of the case study is cited as a suitable companion to critical realist research, in that it can justify "the study of any situation, regardless of the numbers of research units involved, but only if the process involves thoughtful in-depth research with the objective of understanding why things are as they are" (Easton 2010: 119). A comparative case study approach underpinned by critical realism can be both "abductive and retroductive, letting theory inform the selection of cases while using the collected data to refine theoretical understandings" (Bergene 2007: 12).

## 3.2 The Research Process

In this section I discuss how the research progressed, from the initial selection of the case study cities, to the selecting of interviewees, and to the coding and analysis of the empirical data.

Initial work for this PhD involved the drafting and design of a structured research proposal during the first year and a systematic examination of potential cities around the world that may be useful for further investigation. Once the proposal was submitted (and ethical approval for the research was granted) I undertook desk-based research by exploring several databases with details on cities involved in 'smart grid' or 'smart city' projects. Most of these projects involve technological innovations to energy, water or telecommunication infrastructures with opportunities to reconfigure the roles between producers and consumers and to alter the socio-political landscape. From my previous academic work at Durham University I had access to a colleague's smart grid database containing information on 45 cities (nine from the UK, 18 from continental Europe, 12 from North America and one from Australia). This offered a background on the diverse range of infrastructure projects underway as well as an initial glimpse into the social and political implications of technological innovations. However, most of these projects were concerned primarily with the energy sector with minimal interaction with other infrastructures. From here I examined several cities in more detail that could offer the potential for cross-sectoral transitions. Lyon, with some 40 smart projects in development, was seen as a potential case study for this research. Stockholm was also considered. However, a number of major obstacles soon became apparent. First, my own language barriers (unable to speak French or German) could be a potential problem. Much of the research for this project involves exploring the motivations, constraints and knowledge of various experts involved in infrastructural management and without being able to fully explore the nuances and subtleties involved in oral communication I would struggle to gather any meaningful data. Second, several of the cities in Europe are experimenting with novel and unique technologies and, as

such, are already subject to intense academic scrutiny from various other universities. Much has been written about the progressive nature of Stockholm's urban planning processes, for example, and while there may always be something else to add it may be more productive to look at a city that is not under such scrutiny. Because of these issues the three cities chosen for the project are Seattle, Munich and Sheffield.

### 3.2.1 The Case Study Cities

**Seattle.** Danermark et al (2014) recommends the selection of 'extreme' or 'pathological' cases for research that is underpinned by critical realism, arguing that to answer the question 'How is X possible' we can examine cases in which the preconditions for or against 'X' appear more clearly than in others. Danermark et al add:

> "There are at least two types of case where social conditions and mechanisms are very obvious: first, those where the conditions are challenged and the mechanisms are disturbed; and second, extreme cases where mechanisms appear in an almost pure form… Mechanisms, which are usually hidden as they are counteracted by other mechanisms, become very clearly apparent in certain situations. The force of gravity would… be much more obvious than in normal circumstances if it were brought to act in full force and the ceiling above our heads fell down" (Danemark 2014: 104).

Iacono, Brown and Holtham add that it is important to select "critical, extreme, revelatory cases", in which the phenomenon being researched is "transparently observable" (Iacono, Brown and Holtham 2011: 59). At first glance Seattle would appear to be a perfect candidate for such a research approach, as it appears to be a city located within an environment best suited to facilitating forms of urban infrastructure integration: it is a city with a strong city-scale governance structure with delegated decision-making abilities and publicly-owned energy and water utilities; it is a city with a multitude of infrastructural efficiency, replacement and renewal projects underway; and more than 90 per cent of energy is generated from clean hydro-electric power. The city appears to offer an excellent environment to facilitate the integration of infrastructure (whatever this may mean) and is a prime candidate for a 'best-practice' city: a city in which the mechanisms of infrastructure integration may appear in a 'pure' form.

**Munich.** The second city chosen for a case study is Munich in Germany. Not only does this reduce the risk of an Anglo-Saxon bias to the research but it also complements the potential conclusions by bringing a continental European political culture into consideration. As will be explored in Chapter 4, despite a global convergence towards neoliberal economics there remain strong differences between the liberal concept of US and UK capitalism on one hand and the continental non-liberal interventionist countries such as Germany on the other. Similar to Seattle, Munich has strong city government structures – the city-owned S*tadtwerke* manages the energy, water and telecommunication sectors with a public ethos of state-run infrastructures to facilitate wider market activities. Does this public ethos allow for ideas surrounding integration to be realised more easily

than in liberal countries that take a more hands-off approach to infrastructural management? Munich offers a second, European, example of a 'best-practice' city.

**Sheffield.** The third city under study is Sheffield. Sheffield was chosen not simply for pragmatic reasons (although this did play a part). Being based in the city and having access to a range of stakeholders through academic contacts within the University of Sheffield does offer advantages in terms of cost, time management and reduced need for travel, but Sheffield itself could offer an example of integration in what appears to be a problematic context. Infrastructures in the UK tend to be vertically-integrated, splintered, 'siloed' utilities, run under a profit motive and regulated by central government. Much of the literature suggests cross-sectoral partnership working is severely lacking in the UK. What possibility is there for integration in this context? What can urban actors actually do when power within the UK is heavily centralised, with local authorities arguably acting as no more than 'rubber-stamping' organisations used to implement policy directed from Westminster?

At first examination, these three cities may have little in common with huge differences in population, culture, governance, and politics. However, these case studies can be used to open a window to the institutional factors and contexts at play within the three countries and within the various infrastructural sectors. I will use them to examine the deeper forces at work within the different social and political contexts and to draw generalised conclusions from them. While Seattle and Munich may have powerful decision-making abilities at various governance levels, alongside public ownership of the energy and water companies, Sheffield does not. Instead the three cities offer an opportunity for an exploratory examination of infrastructural governance.

While it may be beneficial to explore the concept of infrastructure integration in other cities the emphasis within the case study approach adopted here is not on the number of cases per se, but rather on understanding how the concept of integration manifests itself within different contexts (Baxter 2000). The aim is to use the three case studies to examine policy and practices in relation to urban infrastructure integration. This approach will allow for analytical generalisations to be made between the three case studies and the combination of individual studies will allow for an in-depth investigation of any larger phenomenon uncovered. The primary data collection methods adopted within this project are the use of semi-structured interviews and documentary analysis, which will be examined in the next section.

### 3.2.2 Semi-Structured Interviews and Documentary Analysis

The interviews were semi-structured and were designed to be on average one hour in length – some were longer, some were shorter. Semi-structured interviews have been described as a key source of information in qualitative case study research (Yin 2003). They are one of the most common forms of qualitative research methods and can act as 'construction sites' for generating knowledge and academic theory (Kvale 1996). Research participants are more likely to be responsive during one-on-one meetings than through questionnaires and are more likely to delve deeper into complex arguments (Sarantakos 2005). Semi-structured interviews can also allow for a degree of flexibility in

which issues are addressed – trying to define a nebulous concept such as infrastructure integration will inevitably touch on a variety of wider socio-political processes at work within each of the three case study cities. My own background as a newspaper journalist provided me with experience in arranging and conducting one-on-one interviews and previous academic research provided me with experience in conducting multiple one-hour long academic interviews. Because of the complicated nature of some of these themes I believe that surveys or fully structured interviews were not appropriate as they would not allow for the deeper probing into the social and political construction of explanations and arguments. Instead, semi-structured interviews can offer a greater opportunity for participants to voice their own point of view, rather than the researcher's own interests being prominent (Bryman 2012). The interviews were essentially "self-conscious, orderly and partially structured" conversations with people (Longhurst 2003: 103).

Once the research proposal was approved I conducted further desk-based research to identify the key decision-makers and gate-keepers involved in the three cities and to identify suitable sites for research. I also familiarised myself with the various institutional and governance frameworks in place in each country (see Chapter 4). This stage of the research process involved document analysis, which can be used in combination with interviews as a 'means of triangulation' to provide an understanding of the processes and issues at work within the three cities, and to allow for the design of semi-structured interview topics (Bowen 2009). Key to this stage of the process was to use documents (council reports, blog posts from potential interviewees, news articles, and histories of the three cities) to "elicit meaning, gain understanding, and develop empirical knowledge" before the field work and interviews were conducted (Bowen 2009: 27). This analysis helped to shape the nature of the interviews, to identify potential participants who would be suitable to interview, and allowed the interviews to be conducted from an informed position.

The semi-structured interviews were mainly conducted with 'elites' involved in infrastructural decision-making. Elites have been traditionally defined as individuals so "placed within the structure that by their decisions they modify the milieu of many other men" (Mills 1956: 112). Yet elites are not a homogenous group of people at the top strata of society. There is huge variance between and across different sectors and a great diversity of what actually constitutes an elite (Moore 2012). For Desmond, elites are "those exercising the major share of authority, or control within society, organizations and institutions [which] stems from the control of human, capital, decision-making and knowledge resources" (Desmond 2004: 264). They can be classified as academic scientists, industry scientists, business managers, state officials and policymakers, covering a wide range of disciplines with a variety of expertise and knowledge. As such, elites cover what Knorr-Cetina has described as a 'transepistemic community' with relationships that go beyond the boundaries of a scientific community (Knorr-Cetina 1982). Those targeted for this project include executives and policy makers involved in city-level governance alongside academics, engineers, technicians, intermediaries and private sector actors.

Once a list of potential interviewees was compiled I began to make initial contact via email. It was made clear from the outset that the research did not involve any attempt to influence or change an actor's behaviour within the organisations under scrutiny, to assuage any fears about my intentions. Those who agreed to an interview were given information sheets on the nature of the project and asked to sign a consent form outlining what the interview would involve, as well as my responsibilities as a researcher. The information sheet and consent form can be found in Appendix A

and Appendix B. Each participant was offered a degree of anonymity, however it was made clear that jigsaw identification may be possible from any published works emerging from this project so full anonymity could not be guaranteed. Organisations and brief job descriptions would be used in any published material. Participants who agreed to an interview came from the organisations listed in Table 3.1. For cost reasons field work in both Seattle and Munich lasted two weeks and was conducted in October 2014 and March 2015. Fieldwork in Sheffield was conducted during the summer of 2015.

| Seattle | Munich | Sheffield |
|---|---|---|
| Seattle City Light corporate director involved in telecommunications | City of Munich's Department of Urban Planning, executive in charge of urban mobility | Sheffield City Council – Place Management Team |
| Seattle City Light customer energy executive | City of Munich project leader in city district development | Sheffield City Council economic development officer |
| Seattle City Light executive level information officer | City of Munich Limux executive officer | Sheffield City Council highway maintenance officer |
| Seattle Public Utilities executive level officer | City of Munich's Department of Urban Planning transport officer | Sheffield City Region executive officer |
| Seattle Public Utilities Inter Agency officer | City of Munich's IT Department | Sheffield City Region SCRIF coordinator |
| Northwest Energy Coalition | *Stadtwerke* Augsburg executive officer in energy services | Sheffield Chamber of Commerce executive director |
| City of Seattle's Department of Information Technology executive level officer | *Stadtwerke* Augsburg project manager | South Yorkshire Passenger Transport Executive, transportation and highways manager |
| City of Seattle's Office of Cable Communications executive level officer | Member of Bavarian parliament | Director at Veolia – contracted waste management company |
| City of Seattle transportation executive | Siemens executive | Member of the Sheffield City Region Local Enterprise Partnership |
| City of Seattle planning department executive | Third party infrastructure consultant with expertise in integrated renewable energy | Sheffield LEP chair |
| University of Washington Technology Law and Public Policy academic | | Director of Creative Sheffield, an arms-length business management consultant |
| University of Washington Urban Studies academic | | |
| Third party energy consultant from Northwest Energy Coalition | | Sheffield Highways Maintenance |
| Third party consultant from Envirometrics | | |
| Former City of Seattle technology officer | | |

**TABLE 3-1 RESEARCH PARTICIPANTS**

There are several problems associated with any research project that intends to conduct elite interviews. First is the challenge associated in 'researching up', incorporating a clear power differential between the researcher and the researched. The researcher could become "dependent on the cooperation of a relatively small number of people with specialized knowledge, and not usually a potential emancipator or oppressor" (Desmond 2004: 264). A second problem associated with elite interviewing is access. Smith (2006) argues that elite groups are more difficult to penetrate than other groups, being better equipped to protect themselves and better positioned to manipulate research results and dissemination. Many of the interviewees are highly skilled individuals with high levels of responsibility and little free time. As such I was dependent on rearranging my own schedule to fit the availability of others. This became a problem while carrying out the field work in the city of Munich: several key targets were not available during the short time period in which I had to conduct the field work. As such I broadened the scope of the research to include the Munich city region and conducted interviews with decision-makers from the nearby towns of Augsburg and Ingolstadt.

All interviews were recorded digitally and saved to a password-protected laptop. These recordings will not be made publicly available and will only be accessible to those directly involved in this research project.

Each interview followed a similar format. First, I explained the nature of the research to the participant, the rationale of the project, what I was examining, and my reasons for being in the specific city (Seattle as a potential best-practice case study in integration, Sheffield as the opposite) Second, each interviewee was initially asked the same open-ended question: "what does infrastructure integration mean to you?" I asked each participant to explain what came to mind when presented with the concept of integration, if anything. It was important here not to simply repeat verbatim the research questions set in Section 3.1.1, in order to keep the interview as open and 'natural' as possible. Indeed, a critical realist approach argues against simply converting research method questions into research interview questions (Roberts 2014). Instead, the participants were encouraged to talk freely about their roles and their beliefs, and the interview became a "conversation with a purpose" (Berg 2004: 13). This allowed for an exploration of the 'messiness' involved in infrastructural management. Next the interview progressed according to the participant's day-to-day responsibilities with questions regarding the nature of their work, their interactions with colleagues in other infrastructural domains, and then onto wider social, political and economic issues present within the specific urban context.

### 3.2.3 Coding and Data Analysis

The final stage of the research process took place on my return to the University of Sheffield. All digital recordings were transcribed and loaded into the NVivo software suite for coding. Nvivo is a computer assisted qualitative data analysis (CAQDAS) package that can help create a detailed collection of material to be used for handling, coding and as an aid to understanding the key themes that emerged during the research process (Cook and Crang 1995). Key here is the need to immerse myself into the material, to become familiar with the main themes and discourses to be able to gain

an overview of the depth and breadth of the subject. Cope (2000) has outlined three main purposes for coding qualitative material: data reduction (to group the material into key themes), organisation and the creation of searching aids, and analysis of the material. It is accepted within critical realism that there are differences between the empirical, the actual, and the real, with data, understandings and interpretations being collected from actors and the institutional structures they work within (Easton 2010: 124). As a result, any explanation arising from that data would by necessity be fundamentally interpretivist in character.

A number of researchers urge caution when using computer packages such as Nvivo in qualitative research. Stern (2007), for example, argues that such programs can hinder theory generation while Seidel (1991) argues that such software may 'guide' researchers in a particular direction. Welsh (2002), however, argues that CAQDAS suites can "facilitate an accurate and transparent data analysis process whilst also providing a quick and simple way of counting who said what and when, which in turn, provides a reliable, general picture of the data" (Welsh 2002: 5). CAQDAS are also more efficient than manual coding methods and, because the codes can easily be reworked, renamed and reclassified, it can help when dealing with complex and hierarchical systems of coding (Harding 2013).

For the purposes of this project Nvivo served mainly as a data management tool. It was used as an aid to sort and group the various topics that were raised during the interview so they could be used in a code and retrieve method (Bryman 2012). These issues could then be explored further through secondary research. The main themes that were highlighted emerged through constant engagement with the research questions helping to create an understanding of the wider political contexts of the case study cities. While CAQDAS software is useful in documenting the relationships between observed empirical realities and in connecting common themes from disparate sources, the main aim from a critical realist perspective is to focus "very much on explanations of what brings about these events" (Crosthwaite et al. 1997: 7). These themes were iteratively developed throughout the analytical process. As Crang (2003) argues

> "Analysis is not simply an issue of developing an idea and writing it up. Rather, it is thinking by writing that tends to reveal the flaws, the contradictions in our ideas, forcing us to look, to analyse in different ways and rethink" (Crang 2003: 130).

Cowley (2000) argues that in qualitative research the data are regarded as paramount and "hypotheses or propositions tend to be regarded as 'hunches' to guide analysis and questioning of the data" (Cowley et al. 2000: 223). These conceptualisations can be amended in light of the data that does not fit preconceived conceptions, which was the case during this project. For example, one issue that arose during the fieldwork in Seattle was the importance of the regulatory structure within Washington State that prohibits certain forms of infrastructure integration from occurring. However it was not until the data analysis process began that I was able to fully develop the idea and accurately describe the concept of *judicial splintering*. While many key issues were identified during the fieldwork, the connections between various concepts, the interpretations of certain structures and wider political considerations only began to emerge during the writing of the empirical chapters.

Other themes that arose during this process included issues surrounding the urban organisational and governance structures within the three cities, the abilities of decision-makers and gate-keepers

to act upon their knowledge, the potential for organisational or technological innovations, and the potential for cooperation and resource pooling between organisations. The material that emerged during this data analysis process forms the basis for the three empirical chapters (Chapters 5, 6, and 7). All three chapters share the same structure. First, I discuss the institutional setting of the case study city, outlining the governance frameworks and economic environment of the city and describing the important aspects that may influence infrastructural management. Then, I outline the interviewee responses on the meanings of infrastructure integration. Following this, I aim to explore deeper into the themes that arose during the research and aim to explore the issues that may impact upon infrastructure integration. Each chapter ends with a discussion on the issues raised, with an attempt to categorise the forms of infrastructure integration that exist within each city.

In the next chapter, I seek to place the three case study cities into wider context, with an in-depth examination of the institutional, regulatory and governance structures that exist in the United States, the United Kingdom, and Germany.

# 4 VARIETIES OF URBAN INFRASTRUCTURAL MANAGEMENT

As explored in Chapter 2, the context for infrastructural management and integration is likely to be shaped by a range of organisational, institutional and political factors at a national, sub-national and local level that are historically embedded but may be subject to change. This chapter sets out some of the factors that might shape the institutional and organisational contexts for infrastructure integration in the three countries that form the basis for empirical investigation in this PhD. The chapter draws particularly on insights from the work of Lorrain (2005), who explores the diversity of institutional arrangements in European countries and their translation into infrastructural management. The central conceptual argument is that there are fundamental differences in the institutional structures of the three countries, with variations between countries in terms of the differing roles of the citizen, the state and the market; the locus of power between central, regional and local levels of state governance; and the form of infrastructural provision that should be guaranteed and universal. These differences manifest in how infrastructures are managed and can influence the unspoken rules and cultures of a nation. This is important for a comparative case study approach as wide "generalizations cannot be made" (Lorrain 2005: 233). It is my argument that there are stark differences between the United States, the United Kingdom and Germany in how infrastructural networks are governed. The conceptual differences between the three countries explored in this chapter are summarised in Table 4.1.

I argue that the United States operates with a weak federal government forced to adopt carrot and stick approaches of finance and regulations to promote its policies to the state and city levels of government. The United Kingdom, in contrast, has a strong centre able to promote more market-friendly and profit-driven policies, often against the will of the local level of governance. While the United Kingdom and the United States are often jointly categorised as Anglo-Saxon, neoliberal free market economies, there are important differences between them: for example, in the relationships between central and local government; the ability to enact quick and drastic policy shifts on a nationwide level; and in the differing emphases towards cities or citizens. Germany, in contrast, acts as a networking state with partnership operations across all vertical areas of governance (federal, state, local) and horizontal levels between business, unions and third parties. I will now explore the nature of each country's institutional structure in detail before examining how this may affect the potential for infrastructure integration.

| | USA | UK | Germany |
|---|---|---|---|
| Form of governance | **Complicated federalism.** Incentivising federal state, with locus of power at state and city level. Backed by constitutional legitimacy, elected representatives and professional municipal class | **Highly centralised unitarist state.** *Ultra Vires*. Local authority relegated to implementing state policies and can be abolished at will | **Cooperative federalism** Strong presence of 'networks', with vertical and horizontal networks pervading the entire political and admin system |
| Policy formation and diffusion | **Pragmatic incrementalism** Relatively weak centre, restricting speed of policy change and scale of implementation | **Pragmatic elitism** Power concentrated into hands of a few, rather than pluralistic. Quick to respond to policy changes | **Organic interventionist** Political collectivism. Cooperative partnerships between trade unions, state, businesses and citizens. State should intervene to correct perceive market failures, |
| Form of infrastructural governance | **Sectoral, functional bodies** Allows for concentration of expertise to allow technological innovations and experiments | **Sectoral, functional bodies** | **Territorial** Functional bodies seen as too fragmented |
| Informal regulatory institutions | **Competitive neoliberalism** Cities develop to compete internationally. Infrastructures adapted to meet local socio-political culture. | **Neoliberal individualism** Fair and effective competition promoted within infrastructural sectors. | **Incrementalism** Gradual change and adaptation, continuing role for powerful industry associations. |
| National strategies towards supranational regulation | **Aggressive exportation** Chicago School and Washington Consensus promoting global support for liberal democratic capitalism | **Aggressive exportation** Support for EU legislation for liberalized markets to 'export' British regulatory model | **Defensive adaptation** EU regulation used to adapt to new conditions, aid development of strong firms domestically to meet foreign competition and help overseas expansion |

**TABLE 4-1 THE INSTITUTIONAL CONTEXT OF THE USA, UK AND GERMANY (LORRAIN 2005, JONG, LALENIS AND MAMADOUH 2002, LOUGHLIN AND AJA 2006)**

## 4.1 The United States

The United States is the world's largest economy and is often presented as being the exemplar of a free-market, liberal state. From Chicago School economists who have pushed the concept of neoliberal thought to other countries, to the Washington Consensus that promotes the idea that liberal democratic capitalism is the only ideology that leads to stable nation states, with a pluralist conception of the state emphasising individual interests over the continental European preference towards social action. However, rather than being the paradigmatic model for a non-interventionist free market economy the country is a patchwork quilt of differing ideologies and socio-political cultures containing a mix of free-market capitalism, coordinated public and private partnership working and sometimes public-led infrastructural provision. While the United States may seek to open up markets abroad, at home it is often protectionist, insular, and pragmatic as opposed to blindly ideologically capitalist. It is these differences within the country that has led to the fragmentary structure of governance that exists today. A summary of the management of the country's infrastructure networks can be found in Table 4.2.

### 4.1.1 The Need For Internal Improvements

It has been argued that the US has a "Janus-faced" view of infrastructure (White 2012). Large technical systems are seen as essential to the stability and prosperity of the country yet policy makers and tax payers often baulk at the vast sums needed to install and maintain the national infrastructure networks: today it is estimated that the country needs to spend around $2 trillion to update and repair the nation's ageing roads, rails, bridges, canals, water pipes and electricity networks (White 2012). From the very creation of the United States there have been debates over the role of infrastructures in economic life and arguments over who should pay for the upgrades. Early constitutional debates focused on the role of the federal government to create 'internal improvements' and the desire to raise productivity by improving transportation and telecommunication technologies (Cain 1997). The creation of national infrastructures was essential to integrate the vast interior region of the country to the trading ports on the Atlantic (Larson 2001). However, the lack of sufficient private capital to create these needed infrastructures meant the national federal government had to step in. While early ideologues in the newly created republic favoured diminished state control over assets and pursued libertarian policies towards private enterprise, pragmatism associated with the high costs needed to create and maintain the new national infrastructure networks meant the federal and state governments had to provide initial finance. It was, however, believed the government should only act as a spur for private development and "once the projects generated sufficient revenues, they could be sold to private companies and the proceeds used to promote further internal improvements" (Cain 1997: 120). It was these initial experiments in financing and governing large infrastructures – such as the vast westward expansion of railroads – that created the corporatization policies towards big business. The corporate form of organisation was the only way these companies could access the necessary capital to fund expensive

railroad expansion and, in “exchange for a special franchise charter, the business agreed to have its operations overseen by government” (Cain 1997: 133).

Throughout US history infrastructure provision has been used to spur economic growth and create employment – policies that have continued to the present day. President Franklin D Roosevelt used infrastructure development as the bedrock to his economic stimulus programme during the 1930s depression, which continued into the post war period (Tobey 1996). The New Deal saw huge federal spending on infrastructure improvements to connect and integrate the states while also supplying millions of unemployed Americans with jobs, leading to infrastructure being viewed as a national public good – publicly-funded projects that could be constructed, maintained and operated by the government for the greater good of citizen quality of life and economic growth (Modarres and Dierwechter 2015).

During the 1970s global shifts led to changes in how infrastructures were financed and delivered, alongside a decline of the Fordist-Keynesian model in many English speaking countries leading to transitions away from supply-side universal provision (Castles 1993, Graham and Marvin 2001). President Ronald Reagan in the 1980s, alongside Prime Minister Margaret Thatcher in the United Kingdom, argued for a ‘rolling back’ of the state, implemented anti-statist policies and embraced economic neoliberalism. However, in the United States this ‘hollowing out’ of the state was not uniform across the country and never achieved the level of ‘completeness’ that it did in the UK. It did lead to a reduction in public federal intervention that had become customary in the post-war period. However, while there was a retrenchment at the federal level this was not followed by retrenchment at the state or local level of government. Instead each individual state took their own view on how their infrastructure networks should be governed, implementing Reagan’s policies only if they chose to. While Reagan did reduce the level of the federal government as part of his ‘New Federalism’ policies, state and local authorities often grew to counterbalance the reduction in infrastructural governance. The growth in state responsibilities has led to local frameworks being praised as “filling a missing regulatory enforcement gap in the face of federal retrenchment” (Teske 2003: 291). This downwards direction of regulatory capacity has led to the patchwork quilt in infrastructure provision that exists in the US today.

| | Water | Sewage | Waste | Heating | Energy | Transport | Telecommunications |
|---|---|---|---|---|---|---|---|
| **Organizing authority** | National federal regulatory standards, adoption of 'carrot and stick' governance structure. | | | National regulatory body provides grants and loans to spur commercial development. | | Local authorities for public transport. Federal for rail and interstate | Federal regulatory body to guarantee standards, access and compatibility |
| **Other Actors** | Utilities which supply customers. General service companies which supply services to utilities and customers. | | National EPA organizing authority.<br><br>20,000 small waste management companies<br><br>8 large interstate companies | Few district energy projects in US. Of those, most are non-profit, municipally or community owned. | Industry suppliers, energy service companies and technological innovators. developments | Private national operators for interstate and logistics. | Large vertically integrated national companies. Local and city authorities own municipal cable companies. |
| **Principles** | Towards a more holistic cycle method, reusable water and recycling. | | | No single, centrally-managed policy. | | | |
| **Culture** | • Technological development and ecological modernism emphasised over conservation, related to competitive cities ethos and smart city developments.<br>• Domestic security – energy independence and stable water supply.<br>• Pragmatism – solutions tailored to local socio-political cultures.<br>• Municipal excellence with highly educated civil service. | | | | | | |

**TABLE 4-2 THE UNITED STATES. BASED ON LORRAIN (2005)**

### 4.1.2 COMPLICATED FEDERALISM

The United States government has a federated structure with powers and responsibilities split between the national federal government, state authorities and local level municipalities, cities and districts. The form of 'complicated federalism' with its variety of vertical checks, balances and thresholds, has evolved in a country divided upon how and when to use government interference to solve social and economic problems (Teske 2005). The tensions between state and federal level are continuous and often bitter however, unlike in the UK, it is the federal government that is constantly forced to defend its own existence and justify its interventions in what can be seen as internal state matters (Cain 1995). Part of this is due to the widespread distrust of federal government power that emerged from the popular reaction to the 'taxation without representation' policies carried out by imperial Britain (Norton 1993) leading to the complicated system of checks and balances that limit central power. Another part is that while the UK can, and often does, change its local level of government by abolishing authorities or restructuring regional models at will (under the *ultra vires* principle described below) in the US the states have powers codified under the US constitution. Powers are only relinquished to the federal level if considered necessary to create a strong central government. States have authority in all areas that are not delegated to the federal government under the constitution. As such the states have considerable independence in their activities in relation to the federal government. As De Jong and Haran state they "have their own constitutions, have great financial freedom and have legislation that is not necessarily inferior to federal legislation" (De Jong and Haran 2002: 210). Overt central government intervention in state matters is unlikely and rare. The states are seen as the most trusted and capable partners by citizens and the federal government largely leaves internal state policy alone (Teske 2005).

Today urban infrastructure provision is largely financed by state and local governments – in 2014 state and local authorities spent $320 billion on water and transport infrastructure compared to $96 billion by the federal government (Figure 4.1: Schrager 2016).

Infrastructural management and governance operates as a patchwork quilt of differing policies, structures and ownership models reflecting the various state politics, cultures and ideologies. While the federal government can set national regulatory standards to be met and provide funds (grants and loans) for their policies to be carried out, the choice of how to meet the standards and regulations is largely left to individual states and local authorities. The federal government cannot force its policies on unwilling state authorities. Instead it operates with a carrot (loans, direct grants) and stick approach (regulations, financial penalties). As O'Toole outlines for wastewater management the "design at the national level allows for a huge range of choice among the states, and that this potential for choice is being exercised" (O'Toole 1996: 241).

All 50 states operate Public Utility Commissions (PUCs) as the prime mechanism to govern their internal infrastructures such as electricity, natural gas, telecommunications, and water. The PUCs have been described as "arcane in nature, often of low visibility but sometimes of great salience, which have considerable staying power on the merit, and whose decisions in the essential industries matter a great deal to the public" (Jones 2006: 8). Unlike the continental European form of regulation, one key task for the PUC is to manage, promote and foster competition within

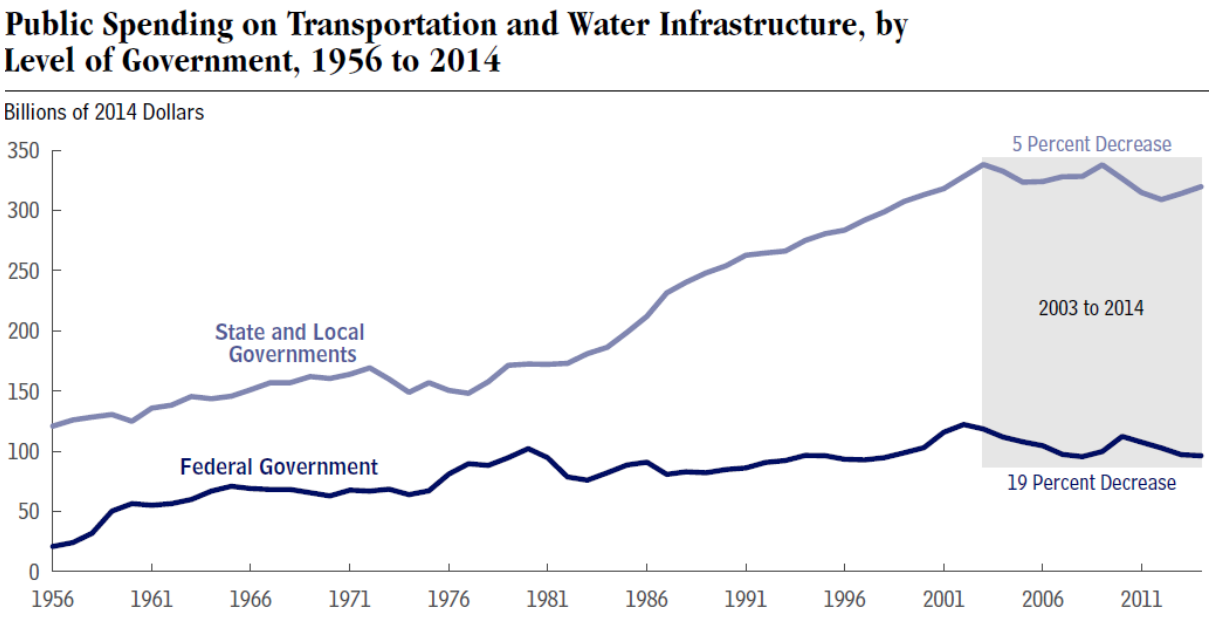


**FIGURE 4-1 PUBLIC SPENDING ON TRANSPORTATION AND WATER INFRASTRUCTURE (CONGRESSIONAL BUDGET OFFICE 2015)**

infrastructure sectors (although not all: water remains a monopoly whether managed publicly or privately). They provide a regulatory function for the internal state infrastructure markets and offer social oversight to (in theory) keep consumer prices low, prevent monopolistic behaviour from private companies and to create an environment to foster innovation and technological advances. They also differ from the European model by acting as functional bodies set up to regulate defined sectors (electricity, gas, water etc.) rather than focusing on boundary-restricted territorial entities (De Jong and Haran 2002). While this does remove the need for geographically-tied authorities restricted by urban, regional or state boundaries, it can create problems for integration between and within the infrastructure sectors. For example, for electricity, although competition is promoted within the retail and generation sectors, transmission and distribution remain monopoly activities and as a result are heavily regulated by the PUCs.

While all states have PUCs to act as market overseers states retain a mix of both private and public utilities according to their own history and socio-political cultures. While most monopoly utilities are private operators (known as investor-owned utilities) a number of cities still retain public ownership of their key infrastructures. In energy policy, the US does not have national laws that constitute a competitive national wholesale and retail market model. Instead energy policy is largely left to individual states and policies can differ between cities even within the same state. In Texas, for example, although policy makers claim they have one of the most deregulated energy markets in the world a number of cities (such as Austin and San Antonio) still have energy and water utilities publicly owned by the cities themselves. California largely operates a market-orientated system while cities elsewhere (such as Boulder, Colorado) use investor-owned-utilities operating under a monopoly contract. The lack of any overall national agenda has led to small utilities operating

discreetly in their own franchise area with little incentive to branch out and join a wider grid. Across the US only a few states have “established formal investment planning criteria or operated a formal investment planning process, relying instead on utilities to do so under the general legal obligation to provide safe, reliable and economic service to retail consumers” (Joskow 2005: 98). These state variations filter through to perceived needs to respond to climate change: some states may see climate change as an economic opportunity for technological development, others may focus on adaptation, while other states may deny the existence of climate change entirely.

The federalised nature of the country leads to the federal government acting to ‘nudge’ states to adopt policies without overt coercion. The country is highly federalised and, unlike in the United Kingdom, central government interventions in state or city matters are unlikely. While a key Reaganite approach in the 1980s was to deregulate the telecommunications industry and promote competition into local state markets, nearly half the states (23) did not change their rates or allow for any form of competition (Teske 1991). Today many cities manage their own cable and telecommunication companies under the PUC remit. The federal carrot and stick approach of loans and regulations applies to other infrastructures. For public transport, federal appropriations have increased from $3.9 billion in 1995 to $10.7 billion in 2015 mostly through the use of the Mass Transit Account of the Highway Trust Fund which receives money from the federal fuel tax and can be used to provide grants for local transport provision (APTA 2015). Another example is the Transportation Investment Generating Economic Recovery (TIGER) discretionary grant program which can be used for local public transportation schemes. Similar programmes exist for energy (such as the Department of Energy’s State Energy Program (SEP) to encourage states to contribute to national energy goals; the Energy Efficiency and Conservation Block Grant (EECBG) to manage energy efficiency and conservation) and for water and waste management. For waste, while it is a $75 billion industry with more than 20,000 companies (although just eight companies take up 50% of the revenue) management variations exist at the state level around local climate (sunnier states have higher levels of garden waste), differing bandings on landfilling, deposit laws and variable rate pricing for waste collection services. The states are left to apply for the funds if they need it and are able to direct resources to where they are (in theory) needed most. As O’Toole argues, the federal government utilises “both the carrot of federal grants and the stick of regulation to induce action” (O'Toole 1996: 230).

One problem with this approach is that projects can be configured to spend available funds rather than to meet long-term public needs (Miller et al. 2000). The federal and state governments outline what funds are to be made available for infrastructure provision and this is then divided up amongst the successful bids. It does however leverage the locally-produced decision-making capacity in place in many states and cities. One reason why this is an advantage to local governance in the United States is the highly-professionalised class of city managers that exist, mainly due to a century of reform in municipal education and civic service.

### 4.1.3 A Professional Class of Municipal Managers

Municipal reform in the United States has been on-going for more than a century. Movements to create an educated and professional class of city managers that could govern local districts and city administrations evolved during the Progressive era in US politics at the start of the 20th Century (Wheeland, Palus and Wood 2014). The aim was to improve urban life and governance through "such reforms as home rule for cities, direct government (initiative and referendum), nonpartisan elections-at-large, the short ballot, the merit system, employment of professionally trained personnel, and strict supervision of city contracts (Griffith 1974b, pp. 25, 34, 59)" (cited in Knoke 1982). One key change the reformers achieved was the professionalization of the civil service and city authorities. Civic service, once seen as a stepping stone for ambitious politicians, became a long-lasting and well-rewarded career in the reformed cities. Decisions could be taken that would benefit the entire community rather than by politicians favouring their local ward voters. This transformed the decision-making structure into a more business-like framework and the civil service became a profession. While this may have lessened the democratic accountability in some cities it did lead to city decisions being taken based on efficiency, performance standards and professional norms (Wheeland et al. 2014). This has, however, led to "policy making in general [being] a relatively slow moving process, with decisive action difficult to accomplish, and with much of the policy initiative displayed, not by elected officials, but by prominent community groups, business firms, other governments, or the city manager" (Clingermayer and Feiock 2001: 11). The advantage of this system is that educated and knowledgeable actors are able to innovate and experiment in their own areas of expertise. However, this ideal of honesty, impartiality and efficiency can favour procedure over substance. Democratic principles of citizen input can be bypassed and actors are often insulated from public opinion. It has also created an "agency-based decentralization of political power, duplication of services, red tape and a concern for self-preservation" (Gluck and Meister 1979: 116).

In an attempt to avoid these difficulties, the National Municipal League promotes good local governance through its Model City Charter which has been adapted and changed eight times since its initial creation in the early 20th century. The model promotes the council-manager (administrative) form of local government as the ideal, as opposed to the more political mayor-council form. Again, however, local communities are recommended to adopt whichever form of local governance they prefer. There is no central diktat as to what should be applied. As Wheeland, Palus and Wood describe, the "political situations and motivations idiosyncratic to individual localities have also been identified as playing an important role in institutional selection and change" (Wheeland et al. 2014: 14). They add:

> "…when municipal reformers today debate about government structure, they can choose from a menu that allows an *à la carte* approach or an *à prix fixe* approach. For example, reformers choose structural features from different forms leading to the adapted city *(à la carte*) or they choose a charter from among a list of basic plans provided under state law (*à prix fixe*) resulting in the continued relevance of the basic plans or forms of government. In states with optional charter laws and home rule, the legacy and adaption of reforms give citizens greater freedom to creatively design a municipal government that aligns with their preferences for citizen

participation, representative institutions, elected leadership, and professional management" (Wheeland et al. 2014: 22).

### 4.1.4 SUMMARY

The literature suggests that US cities operate within a fragmented structure of governance with the locus of power residing at the state and city level, as graphically represented in Figure 4.2. The federal government is restricted to act in an incentivizing role in nudging states and cities towards centrally-favourable policy directions. As a result, national policy-making can be slow to react to events, radical changes can be difficult to implement, and states and cities are largely free to follow a direction of their choosing, albeit by agreeing to abide by the regulatory authority ceded to central government. Cities themselves act in competition with each other to attract citizens and businesses, differentiating themselves from other cities by developing their own strengths, providing the necessary quality of life for residents and offering a mix of infrastructural provision according to their own socio-political environment.

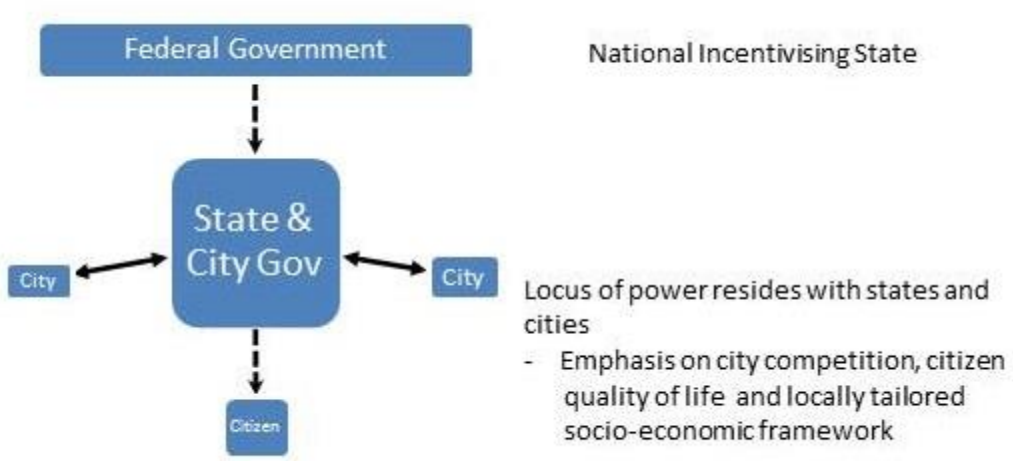


**FIGURE 4-2 THE US STATE**

What does this mean for the potential for infrastructure integration? The sectoral governance model makes it difficult for infrastructures to be managed under one roof in a way similar to the territorial model followed by continental European countries despite the opportunity for the PUCs to act in more coordinated ways. Also, the slow pace of change within governance networks created by the fragmented federal structure could filter through to attempts to introduce innovations within infrastructures when they arise or are needed. The opposition to Reaganite reforms in telecommunications is a good example. However, these potential problems may be offset by the power locus set within the state-level governance structure. A highly educated, professionalised, career-driven civic structure could offer experts influence over utilities without the threat of external political influence. City managers may feel they can deploy renewable technologies despite the

existence of politicians who deny the existence of climate change or who rely on the relatively cheapness of energy within the US. The decentralised decision-making structure allows for innovative cities to act quickly within their own locales without seeking prior approval from the federal centre, and the desire to integrate the US on a geographic level (through telecommunications, road and rail networks) has been a common discourse since the country's creation. At the local level cities have strong incentives to ensure adequate provision of infrastructure – infrastructure can provide for urban growth (both economic and population) which in turn helps to pay for further developments in infrastructure. However, the patchwork quilt nature of policy and the relatively weak federal centre may make it difficult for any meaningful 'integration' to occur on a national scale. If and when integration does occur, it may be local, small-scale and sector-specific. One issue is the varying capacity to shape infrastructure in different cities, and cities have different challenges and different assemblages of inherited infrastructures. What may be an appropriate set of policy tools for infrastructural management in Seattle may be different to what is needed in Atlanta. As such, it will be difficult for any research project to draw conclusions that can be generalizable to the whole United States when studying a single US city.

## 4.2 The United Kingdom

In many regards the United Kingdom can be described as the classic variant of liberal market economies. The country is heavily reliant on competitive market relationships underpinned by common law and formal legal contracting; it adopts policies that emphasise the individual citizen over a more diffuse conception of collective society; and it aggressively seeks to export its policies worldwide (Hancké, Rhodes and Thatcher 2007). However, while the United Kingdom is similar to other Anglo-Saxon countries there are a number of important differences. There are differences in the locus of power and the role of the centre compared to the local level of government. While the United States federal government seeks to influence state and city level authorities (as it is the federal government that is not trusted and is forced to justify its role in internal affairs) in the United Kingdom it is the central government that can dictate policy to its lower levels of government. Since the layers of government can be reorganised, restructured or abolished at will by the central state, it is the private sector that the UK government seeks to enable, often at the expense of the local public sector.

### 4.2.1 UK Governance Structure

The United Kingdom is an exceptionally centralised nation given its size: there is a large bias politically, administratively and in terms of population towards south east England, focusing on the capital of London at the expense of the sparse periphery regions. London, and specifically Westminster, is where power lies within the UK state. The UK has shifted wildly from macroeconomic Keynesian policies to achieve full employment with activist fiscal policies in the post-war period to Thatcher-backed monetarism in the 1980s and 1990s. While the UK and (West)

Germany had similar institutional characteristics governing their infrastructures the challenges that arose in the 1970s (reduced investment, increased prices to maintain profitability and loss of public esteem) caused their institutional paths to diverge, with the UK moving away from the continental model of state-owned utilities towards a model of regulated competitive markets (Thatcher 2007). The UK variant of capitalism is underpinned by formal legal arrangements and reliant upon competitive market relationships: most areas of public policy revolve around the power of the market (Hall 2001). The UK also has an adversarial nature of politics compared to the consensus-seeking model practiced in continental Europe with decision-making operating "between proposer and opposer, prosecution and defence, government and opposition, without much value being given to the positions between these poles" (Norton 1993: 361). The Coalition government elected in 2010 – made up of the majority Conservatives and the minority Liberal Democrats – was the first coalition government in decades.

A pluralist conception of the state, combined with a neoliberal emphasis on the creation and management of competitive markets, means the state does not have to "do everything or decide everything" distinguishing it from the more interventionist continental countries (Lorrain 2005: 244). The concept of the state is one of limited government with an emphasis on the liberal concept of the primacy of the individual, especially in regards to the ability to conduct commerce (Loughlin and Aja 2006).

The adversarial nature of UK governance extends to relations between central and local government. Local authorities have no general competencies enshrined in law but may perform only what is permitted by Parliament, which defines the 'powers beyond which' (*ultra vires*) it cannot go. (Loughlin 2006). They have no independent rights and are creations of Parliamentary statutes. There is no binding statement of civil rights nor a codified system of checks and balances to prevent abuse of power. Instead the UK abides by the omnipotence of Parliament. The UK has an unwritten constitution of the 'utmost flexibility' that evolves through common case law and statutes can be changed by simple Parliamentary majorities (Norton 1993). Central government sees local authorities as agencies created to deliver centrally-decided policies: there is no assumption that "local authorities have a right to act in the interests of their inhabitants unless they can quote legal justification or limit their 'free' expenditure to a low statutory level" (Norton 1993: 356). The fact that they can be abolished at will by central government makes them vulnerable and reluctant to implement policies which may antagonise national politicians. Indeed, it appears locally- and centrally-based civil servants "live in relatively separate worlds" with little understanding and interaction between them (De Jong and Haran 2002).

| | Water | Sewage | Waste | Heating | Energy | Transport | Telecommunications |
|---|---|---|---|---|---|---|---|
| **Organizing authority** | Department for Environment, Food and Rural Affairs (Defra)<br>Environment Agency<br>Ofwat | | | Ofgem | | Department for Transport.<br>Local authorities | Ofcom |
| **Other Actors** | 32 privately-owned regulated monopolies.<br>Drinking Water Inspectorate.<br>Consumer Council for Water.<br>Competition Commission. | | Waste Disposal Authorities.<br>Private competition. | National Grid (system operator)<br>7 distribution network operators (DNO)<br>3 transmission companies.<br>Big six retail utilities dominate the retail market | | Private buses<br>Monopoly franchises on rail network. | Open competitive market in phone, broadband and cable. |
| **Principles** | Integration of the cycle | | Separation collection/treatment<br>Competitive tendering | Competitive structure, unbundling Coordination by the pool | | Open competition by lines<br>Pooled coordination | Competitive retail market. |
| | • Functional optimum for institutions and sectoral specialization<br>• Open competition: by line (waste, buses), by sectoral organization (electricity, unbundling) or by third-party access to the network (common carriage)<br>• Elimination of cross-subsidies between sectors and between subsidiaries of the same operator<br>• Emphasis towards "Efficiency, affordability, customer service and competition" | | | | | | |
| **Culture** | • Challenge, conflicts, disputes (recourse to the law), culture of control (agencies, monitoring)<br>• Trust in markets to allocate resources more than in integrated enterprises (role of traders, openings for foreign enterprises): competition<br>• Belief in the importance of institutions. Permanent process of institutional reform | | | | | | |

**TABLE 4-3 THE UK'S INFRASTRUCTURE NETWORKS. BASED ON LORRAIN (2005)**

The recognition that local government should act as an all-purpose service provider reached its peak in the 1930s and has declined ever since. Councils were relieved of their responsibility for electricity and gas supply in the 1940s and lost control over water supply, conservation and sewage in the 1970s. Since the creation of the welfare state after the second world war the UK has embarked on a series of centralization policies, reducing local government to the role of administrating policies forced upon it from the centre (Loughlin 2006). Norton (1993) claims this loss of control was due to political weakness, the low weight given to local autonomy and control, and a belief that local authorities were inefficient.

In the 1980s local government was diminished again and councils lost control of their housing stock and flexibility to respond to economic depression. The neoliberal policies of Prime Minister Margaret Thatcher emphasised a minimal state based on individual personal choice and the maximisation of economic efficiency. The core belief was:

> "…governmental institutions, whether at the central or the local levels, hinder the individual's exercise over free choice. In fact, according to this theory, bureaucrats tend to inflate their own bureaucracies and services in inefficient and wasteful ways… the result, ironically, was the strengthening of central government and the creation of new bureaucracies, which Mrs Thatcher allegedly wished to diminish" (Loughlin 2006: 41).

The Thatcher government transferred local council responsibilities such as transport and urban development to QUANGOs (Quasi-Autonomous Non-Governmental Organisations) which acted as agencies of the central state. The government also reduced autonomy over local authority spending and transformed local government into an enabling form of administration, reducing discretion over service delivery by forcing through the:

> "…*privatization* of some services; *limitations* on the proportion of services that can be provided 'in-house', the rest being farmed out to private sector providers; and *compulsory competitive tendering (CCT)*" (Loughlin 2006: 41).

CCT is a means of efficiency, rather than effectiveness, as it was assumed that the private sector could deliver services better than public authorities, with tenders going to the lowest bidder even if it did not offer the best service. From 1997 the New Labour government kept most of the system but introduced a *quality* of service delivery to be included in calculations (known as 'best value'). Rather than learn from local authorities through local initiatives and experimental ways of working that could be overlooked by the centre, central government has instead sought to force policies on to local councils, judging them on the lowness of their expenditures and the extent of privatisations rather than through quality of service delivery. New Labour also centralised powers over economic development and skills training (Bentley, Bailey and Shutt 2010).

Today most council funding comes from central government grants. The *ultra vires* principle does not prevent local authorities from attempts to develop initiatives appropriate to their local community, even if different from national policy, although councils still have to act within the bounds of what they are permitted to carry out.

Locally, elected councillors decide policy in tandem with input from civic officials and senior council administrators. As Loughlin describes it, "probably the most accurate model to describe this is

elitism, which sees power as concentrated in the hands of a few, rather than pluralism" (Loughlin 2006: 43). In England, the Local Government Association (LGA) represents local interests in discussions with central government. Local authorities are much larger than in most developed countries: the average UK local authority has over 150,000 citizens, compared to an average of 20,000 elsewhere (Smith 2013). This means:

> "…that the scale of local authorities being on average much greater, and their number fewer, central government has had an increased focus on performance and outcomes in specific authorities, not just in aggregate terms, and a greater propensity to see it as its task to intervene. This also reflects one side of our (contradictory) historical tradition of local government, which combines a strong sense of municipal self-government, enterprise and sense of local identity, with a more 'instrumentalist' perspective of local authorities as, in effect, akin to administrators of central government policies, or at least as bodies that must be controlled and hedged in by detailed prescriptive rules" (Smith 2013: 7).

The UK has been criticised for deficiencies in its local government structure. In 1997 the Council of Europe passed a resolution that included the UK in a list of countries that had "serious deficiencies in the practice of local democracy" along with Croatia, Bulgaria, Latvia, Moldova and Ukraine, criticising the replacement of local authorities with QUANGOs and stringent centrally imposed limits on local expenditure (Loughlin 2006). The UK structure also favours efficiency over democracy at the local level and citizens view local government primarily as a provider of services rather than a democratic forum where debate can take place.

### 4.2.2 DEVOLUTION

Since the 1990s various UK governments have implemented devolution reforms. In an attempt to address the centralism implicit within UK governance, from 1997 the New Labour government preferred forms of regionalism with the creation of Regional Development Agencies (RDAs) and Regional Assemblies. It was the role of the assemblies to relay opinions and to scrutinise the more business-led RDAs, as well as acting as regional planning bodies. New Labour created devolved forms of government for Scotland and Wales and implemented decentralisation to the subnational level of RDAs in England, charging them with economic development of the regions (Bentley et al. 2010). It has been argued, however, that this form of decentralisation represented nothing more than 'New Centralism' (Corry and Stoker 2002) with attempts to create joined up governance within policy-making leading to control being retained by the centre. New Labour restricted the level of regional and local government with "tight controlling mechanisms, including Public Service Agreements, which controlled service delivery; budgets which were tied into the achievement of targets for centrally devised policy measures; and with policy frameworks, which provide a strategic framework for policy making at the lower administrative scales" (Bentley et al. 2010: 538).

In 2010 the Coalition government was elected and a long-standing Conservative antipathy to forms of regionalism led to the RDAs being abolished during a 'bonfire of the QUANGOs'. The Government Office for the Regions was scrapped, along with Regional Select Committees and Regional Spatial

Strategies. The planning powers once held by the assemblies were returned to local authorities (Bentley et al. 2010). To replace them the Coalition government announced a round of 'city deals' for eight of England's 'core cities' including Manchester, Sheffield, Liverpool, Birmingham and Newcastle. The deals covered areas of transport and infrastructure, jobs and skills, economic development and business support, and funding (Marlow 2012). The shift also saw the creation of 39 Local Enterprise Partnerships (LEPs) to replace the RDAs which were, in theory, partnerships between city officials and civic and business leaders. While the stated aim of these reforms is 'localism' some researchers have been sceptical of the changes:

> "Whilst LEPs are in principle to be responsible for enterprise and business development, the coalition government proposes significant centralisation of key activities related to these functions. European funded programmes, trade and investment, innovation, venture capital, sector support, business support and skills are among the functions being transferred to the national level to be managed mainly by the Department of Business, Innovation and Skills. This is hardly localism. Given that these functions are to be carried out at the national level, it will affect LEPs' freedom to effect outcomes" (Bentley et al. 2010: 551).

The new form of localism was implemented alongside policies of austerity imposed by central government on local authorities, affecting service provision and public employment (see figure 4.3, the figures are distorted somewhat as they include local authority maintained schools being converted into academies, resulting in the categorisation of existing staff being transferred from local to central government).

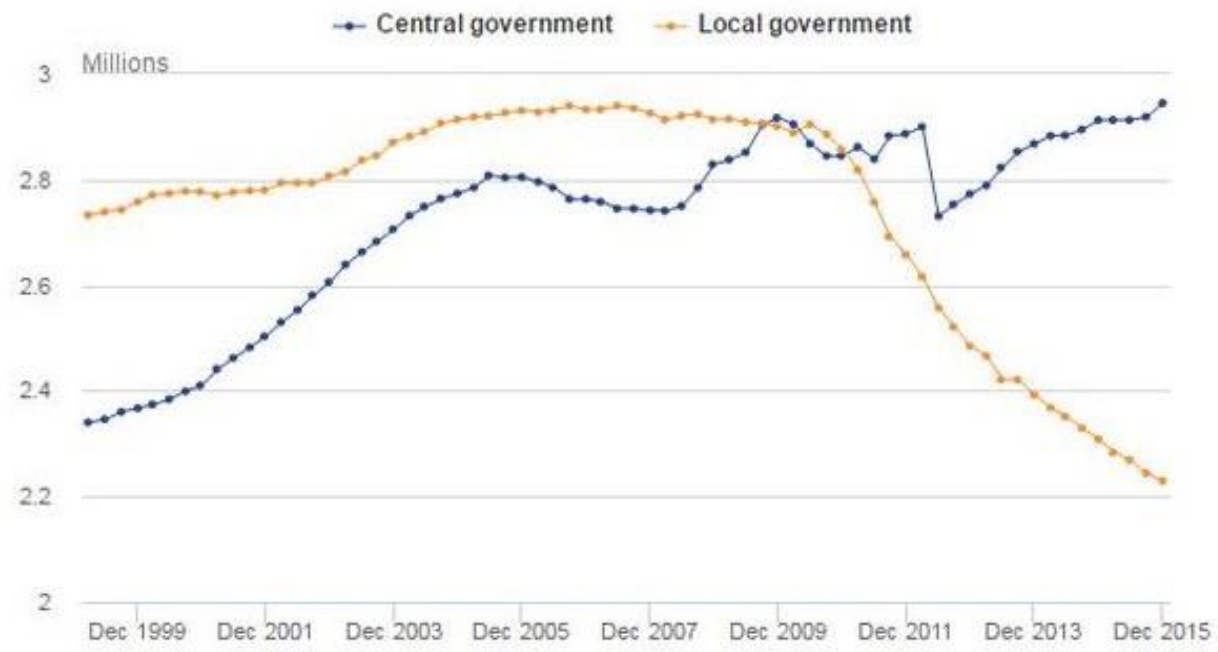


**FIGURE 4-3 UK PUBLIC SECTOR EMPLOYMENT IN LOCAL AND CENTRAL GOVERNMENT, MARCH 1999 TO DECEMBER 2015, SEASONALLY ADJUSTED (ONS 2015).**

### 4.2.3 THE UK'S INFRASTRUCTURAL GOVERNANCE

Thatcherite policies introduced in the 1980s and 1990s led to major shifts in how the UK's infrastructures were governed, away from the supply-side, Fordist-Keynesian monopoly practices of the 1960s and 1970s, and towards neoliberal market reforms with an emphasis on competition and consumer choice. The ability of the government to push through its privatisation agenda was arguably due to the "central role of the ideologically determined government, the lack of major institutional barriers and the ability of the government to override societal opposition" (Bartle 2002: 11). The 1980s and 1990s saw the dismantling of many state-owned infrastructural monopolies and competition introduced into the energy and telecommunications sectors, while monopoly suppliers in water were sold to private interests in the interests of consumer cost reductions and efficiency. While these privatisations may have improved efficiency and reduced costs for the end consumers they "have also led to a fragmentation of sectors such as water and electricity and a blurring of accountability for creating sufficient infrastructure capacity over the long term" (Armitt 2013: 3).

Unlike the German principle of territorial infrastructural governance (see below) the splintered nature of the UK landscape leads to an independent government regulator for each sector. Cross-subsidisation is seen as anti-competitive, intervention by elected politicians is viewed as leading to short-term decision-making and 'fair and effective competition' is paramount (Thatcher 2007). Berg and Blake (2013) highlight three fundamental principles of the UK regulatory landscape: the rejection of rate-of-return regulation; the rejection of direct government control; and the rejection of monopoly provision. These principles form the basis of the RPI-X price cap regulation (the average retail price is allowed to increase alongside the retail price index, minus an X-factor to account for technology changes and productivity improvements) which is instrumental in the electricity, gas, telecommunications and water sectors (Berg and Blake 2013).

The privatisation of the electricity industry in 1990 introduced private retail utilities and regulated transmission and distribution monopolies, with the intention of shifting power within the sector away from the producer and into the hands of consumers, who were now able to choose the supplier of their electricity. A wave of mergers in the industry has led to seven distributer network operators (DNOs) covering the 14 regional areas, four high-voltage transmission companies, and a variety of retail energy companies dominated by the 'Big Six' of British Gas, EDF Energy, npower, E.ON UK, Scottish Power and SSE.

North Sea gas reserves provided for a dash-for-gas in the 1990s and today meets around 70 per cent of all domestic, commercial and industrial heat demands (Arapostathis et al. 2013). This cheap supply of gas necessitated the creation of large nation-wide gas pipeline networks, restricting the control local authorities could have over local heat demand. As a result, the amount of district heating networks in the UK is low and mainly concentrated in hospitals, schools and universities. Local authorities lack the organisational capacity to develop district energy schemes and have traditionally lacked a prominent role in energy planning (Bolton and Foxon 2015).

Up until the early 2000s the newly-privatised utilities, distributer network operators and regulators prioritised consumer cost reductions over investment, leading to neglect in maintenance budgets. Regular price controls imposed by regulators on the private operators has incentivised the network

companies to reduce their operating costs, however there have been concerns raised over the quality of service delivered, including rises in outages and interruptions to supply (Bolton and Foxon 2015). Similar price reduction strategies were introduced onto the railway network when it was privatised from the 1990s until the early 2000s, when a serious of accidents revealed problems in reducing maintenance budgets to keep consumer costs low. While the Train Operating Companies are privatised and manage what are effectively regional monopolies they remain under heavy regulation from central government in terms of fares, timetables, reliability standards and ticketing arrangements (Arrowsmith 2003).

A policy shift in the 2000s led to attempts to introduce innovation into the networks, partly to account for the lack of historical investment in the ageing infrastructures but also to enable a shift towards decarbonisation and 'smarter' technologies – the UK has a target for an 80 per cent reduction in greenhouse gas emissions from 1990 levels by 2050. Similar to Germany the UK did operate a feed-in tariff scheme (FiT) to boost its share of renewable energy sources – remuneration is paid above the retail or wholesale energy price for those who generate renewable energy sources. However, the UK also introduced a number of market-based decarbonisation projects. The Tradable Green Certificate (TGC) scheme launched in 2002 mandated generators to either earn green certificates by supplying a share of renewable energy to the national electricity market, or to buy certificates on the open market from other suppliers. Renewable generators are issued with Renewables Obligation Certificates (ROCs) which can then be traded on the open market. While the scheme has been described as a largely successful decarbonisation strategy with boosts to offshore wind generation, cheaper onshore wind has not developed as quickly due to "important institutional barriers" (Pollitt 2010: 50). Approval rates for onshore wind were 62 per cent in 2010 and it took on average two years to reach a decision, largely due to opposition over amenity impact in rural areas (Pollitt 2010). The national nature of the UK energy market also acts as a barrier for small-scale local generation schemes, either from community groups or local authorities. While the large national companies may benefit from large financial resources to invest in renewable energy schemes they often face local opposition that small schemes may avoid.

The water regulator Ofwat is attempting to introduce retail competition into the traditionally monopoly-based water sector. While the regulator believes 1.2 million businesses will soon be able to choose their water and wastewater services provider they also retain a focus on consumer experience, with a Service Incentive Mechanism being used to adjust utility rates in line with communication, customer engagement, and the nature and speed of response to consumer complaints (Black & Veatch 2016).


**FIGURE 4-4 THE UK STATE**

### 4.2.4 SUMMARY

The central-local governance structure of the UK is graphically represented in Figure 4.4. It is central government that creates policy with an emphasis towards market creation and private provision of services. Local government is weak and often acts merely as an implementation and administrative arm of the UK state. The strong central state, the splintered nature of the UK's infrastructure networks, and an emphasis on the primacy of markets and consumer choice may make it difficult for any meaningful form of infrastructure integration to occur at an urban level. A number of small local schemes do exist, yet they struggle to compete with the large national utilities operating in most infrastructure sectors. While there have been moves towards devolution in recent years (Scotland, Wales and Northern Ireland have their own devolved powers) in infrastructural terms many city regions remain unable to have exert any meaningful authority over the often nationally-managed infrastructures. The national debate within the UK is on the need for infrastructural investment, and cities are keen to upgrade their local networks and capture investment being directed towards smart cities. However, as will be seen in the empirical chapter on Sheffield (Chapter 7) there is a general distrust between national and local civil servants in terms of policy efficiency and implementation effectiveness. The energy, water and telecommunications sectors are still largely the preserve of the large national private providers. These can often be vertically integrated and while a number of companies do operate within multiple sectors – for example Virgin operating in both the rail and healthcare sectors – this form of horizontal integration is rare. In recent years, there has been a shift towards technological innovation and a decarbonisation of the energy supply however, these attempts are still secondary to sectoral efficiency and consumer experience.

## 4.3 THE GERMAN STATE

Germany is the largest economy in Europe and the fourth largest economy by GDP worldwide. Its 21st Century status as an economic superpower may seem remarkable given the devastation wrought upon the country during the two world wars, as well as its split in to two countries in the 1950s and then its eventual reunification in the 1990s. Yet today the German state has become the exemplar of a mixed market economy: a strong public sector, powers split between the federal, state and municipal levels of government, and a corporate, co-determinist and collaborative participatory economic model engaging workers and industry. Germany's collectivist social model has led to the country being described as the ideal co-ordinated market economy (Hall and Soskice 2001), the definition of a Continental European form of capitalism (Bolognesi 2014) with a political economy of a contractual, interventionist state evolving from a 19th Century culture of local service municipal provision (Lorrain 2005). State reforms and governance techniques prevalent in Germany reach back to the country's medieval guild system and the settlement reached between the two Christian confessions in the Holy Roman Empire at the end of the religious wars in the Seventeenth Century (Streeck 2005). Economic life focuses on consensus-seeking and co-determination rather than the competitive and conflictual model practised in more liberal Anglo-Saxon economies such as the UK and US. Trade unions have strong involvement in industry work councils which operate throughout the country, local authorities are strong and willing to intervene to solve perceived market failures, and local decision-making with strong forms of public participation remains a key feature to citizen democracy. The political economy is distinguished by a particular set of institutions that have created a 'socially embedded capitalism' that incorporates the market economy into the reaches of the state with a strong ethos of state-led social reform (Lehmburch 2005). In describing Germany as a form of 'cooperative federalism' Bartle (2002) highlights the importance of "federalism, coalition government, a non-adversarial parliament and the active role of interest groups" (Bartle 2002: 7).

The federal constitution mandates authorities to "ensure equal living conditions on the territory of the Republic" which has been interpreted as the foundation for Germany as a "unitary federal state" (Wollmann et al. 2010a). The strong links between industry, business and public infrastructure is arguably a result of the "social systems of innovation and production based on powerful public intervention by centralised bodies or local authorities" at work in the German state (Bolognesi 2014).

### 4.3.1 THE GERMAN GOVERNANCE STRUCTURE

Germany is a federal state with three interlinked governance levels. At the regional level are 16 states (*Länder*) each with its own constitution and parliamentary system of governance and administrative departments. At the national level is the Federal Cabinet (with the Chancellor and 14 federal ministries), the directly elected Federal Parliament (*Bundestag*) and the second parliamentary chamber (*Bundesrat*) representing the 16 federal states. Each state exercises legislative and political powers over its local authorities, consisting of counties (*Kreise*) and municipalities (*Gemeinden*). The majority of legislation (including European legislation) is enforced

by the local authorities below the *Länder* – about 70 to 80 per cent – making Germany's local government one of the most politically and functionally strongest in Europe (Monstadt and Scheiner 2014, Wollmann et al. 2010c).

While the federal level of government holds primacy in legislation and policy-making there is a strong system of checks and balances enforced by a vertical division of power and complicated through complex political and governance networks that operate vertically through the levels of state and horizontally between the various *Länder* and local authorities. Although the *Länder* have to enforce the areas of law in which the federal government is responsible they are able to participate directly in shaping that national legislation through the upper chamber of parliament, the *Bundesrat* (Wollmann et al. 2010a). Unlike the US, the federal and state levels of government work in parallel with interlinked competencies and a specific division of labour and responsibilities between the two levels of government. Some 60 per cent of federal laws are dependent on the endorsement of the *Bundesrat*. The 'organicist' version of the state in Germany provides a strong theoretical underpinning for local administration – under Article 28 of the constitutional Basic Law German municipalities have full autonomy in regulating local issues such as water and energy provision, housing and transport. They are guaranteed the right to deal with all local matters affecting the municipality and it is not permissible for the state (unlike the UK) to list the tasks for local government to address. The concept of "pragmatic municipalism" (Lorrain 2005) has led to the passing of laws and regulations that recognise the importance of local authorities in providing a city's basic services. While cities are limited by the principle of subsidiarity any intervention from the federal or state level is rare due to the strong concept of local self-government. As Lorraine argues the German model is:

> "…characterized by a pragmatic, gradual, concept of change. Unlike the English model, it does not seek to impose major framework shifts, but to adapt to what already exists. Germany has held to some major policy principles and gradually modernized them" (Lorrain 2005: 243).

This German tradition sees local interests as inseparable from national interests with a local administrative state believed to be the most efficient way to respond to local needs and to enhance national capacity (Norton 1993). The freedom of citizens and state institutions are underpinned by strong local autonomy and the rule of law.

| | Water | Sewage | Waste | Heating | Energy | Transport | Telecommunications |
|---|---|---|---|---|---|---|---|
| **Organizing authority** | Local authorities and districts | | Local authorities | | | | Federal Network Agency (*Bundesnetzagentur* or BnetzA) |
| | | | | | *Bundesnetzagentur* regulates non-discriminatory access to electricity and railway networks | | |
| **Other Actors** | *Stadtwerke* ('City Works') organising authority at the local level. | | | | | | *Stadtwerke* offers local broadband networks. National market dominated by Deutsche Telekom Vodafone, Telefónica Germany and E-Plus |
| | | | | | 'Big Four' energy companies (RWE, EnBW, E.ON and Vattenfall) dominate national market. | | |
| **Principles** | • Strong local public sector: centring on the city level, multi-sector municipal enterprises<br>• Territorial monopoly, concept of network unity<br>• Industrial integration in electricity, oligopolistic structure regulated from above by mechanisms of competition and from below by local elected representatives and municipal civil servants | | | | | | |
| **Culture** | • Concept of change based on pragmatism (gradualism)<br>• Consensus culture, co-production<br>• More importance placed on industrial production factors than on 'institutional design' | | | | | | |

**TABLE 4-4 THE GERMAN INFRASTRUCTURE NETWORKS. BASED ON LORRAIN (2005)**

While all local authorities have the same powers guaranteed under the constitution they are free to pick and choose their own institutional frameworks and their own preferred means of service provision creating a complex picture of differing management and governance schemes across the country. The *Anstalt,* for example, an institution created under public law often used in public service provision, can be set up by authorities and is not regulated by any specific law – it can "thus be designed totally a la carte as regards institutions, powers and public or private partners" (Citroni 2010: 196).

It is the interactions between the three levels of government – federal, *Länder* and local – that characterises German governance. The vertical and horizontal phenomenon of 'networks' pervades the entire political and administrative system. Loughlin et al (2006) outline one example:

> "…the regular meetings between specific ministries (e.g. the conference of culture ministers who are responsible for education policy) have developed into an important working interface between the federation and the Lander at which the preliminary work is done on far-reaching decisions and coordinated with the views expressed by the Lander governments. It generally remains for the Land parliaments merely to endorse the findings" (Loughlin and Aja 2006: 99).

While critics claim this has led to the formation of a 'crypto-unitarist' state in which the *Länder* have seen their autonomy weakened, this form of statecraft does allow for experimental governance arrangements to be trialled, evaluated and then diffused to other authorities. For example, the ability for *Länder* to tailor national federal (and European) policies to their own locally-specific contexts has allowed for the growth of renewable energy grids, decentralised technologies, widespread recycling schemes and subsidized public transport without the need for federal encouragement, oversight or approval.

### 4.3.2 Germany's Infrastructural Governance

The infrastructure of Germany reflects the complications of the political and social changes that the country has faced during the 20th Century. Post-war reconstructions maintained the principles of local self-government and public services were provided under municipal ownership. As a result, in what was the former West Germany at least, there was no widespread nationalisation of the electricity system and many services were (and still are) provided by local public utilities under a form of arms-length service provision, often by organisations known as *Stadtwerke* or 'city works'. While there were close long-term relationships between the publicly-owned utilities and their privately supplied manufacturers the federated nature of Germany led to a lack of state leadership, and West Germany failed to develop large-scale industrial projects such as nuclear power or telecommunication networks (Thatcher 2007). The lack of consensus between political parties and powerful trade unions also forced West Germany to drop plans to alter the status of many publicly-owned suppliers, for example selling off the telecommunications arms of the *Deutsche Bundespost* or the *Deutshe Bundesbahn*. Instead problems were solved through extra public funding and public and private cooperation.

Traditionally infrastructures have been managed on a territorial basis rather than the more sectoral practices that exist in the UK and US: cities and municipalities largely manage and govern their own infrastructures and use forms of cross-subsidisation to keep costs low for their own citizens. However, the wave of New Public Management strategies that were introduced across the continent in the 1990s, alongside the network liberalisation and competition policies enacted at the European Union level, has led to the institutional fragmentation of infrastructural governance within Germany and a convergence towards the Anglo-Saxon models of vertical integration of networks alongside horizontal unbundling. The German pragmatic concept of a single municipal organisation managing a region's entire infrastructure has been called into question and attempts have been made to prevent forms of cross-subsidisation, liberalise infrastructure markets and to open sectors to European-wide competition.

A number of researchers argue that this neoliberal progression of outsourcing and unbundling "has made it more difficult to link infrastructure provision to broader local strategic goals, and also reduced the scope for governments to capture and reinvest growth revenues (Haughton and McManus, 2012; Rutherford, 2008)" (cited in While and Whitehead 2013: 2383). However, this risks downplaying the complicated governance arrangements at work within Germany. The German pragmatic approach does not lean ideologically towards either pure competitive private markets or to regulated public-sector driven monopolies and unlike the UK and US there is no national desire to transform the state into merely an 'enabling' form of government. Instead the public sector remains a valid and useful competitor to private enterprise. While the UK seeks to tinker with markets and regulations to find the most efficient and cost-effective way to provide public services, in Germany the public and private sectors are comparable players within infrastructure governance: if the private sector does not provide universal coverage the public sector will step in and create its own networks. Efficiency is just one important consideration and many municipalities view other issues such as job and business creation, urban quality of life and the integration of space and scale of equal importance.

### 4.3.3 National Unbundling, Local Integration

Today infrastructural management in Germany can be categorised into two groups – those with a national competitive market (energy, rail, and telecommunications) and those without (water supply, wastewater treatment, local transport). However, this risks simplifying the complex arrangements and ownership models that exist within Germany. Many *Stadtwerke* are themselves a mixture of ownership models: some are owned entirely by their respective local authorities; some are operated as publicly-owned but private arms-length enterprises; others are jointly owned by the public sector and international private firms. Vertical and horizontal ownership networks run throughout German infrastructural life. One of the Big Four energy firms EnBW is itself almost wholly owned by municipalities and the state of Baden-Wurttemberg. RWE and E.ON both have subsidiaries holding minority interests in around 100 *Stadtwerke* while only 30 per cent of the *Stadtwerke* are wholly owned by their cities – such as Munich and Leipzig (Wollmann et al. 2010b). These complicated ownership models have developed from long historical roots.

Nationally attempts have been made to introduce competition into the electricity and telecommunications markets (largely due to policies enacted by the European Union) and both are now dominated by large, almost oligopolistic firms. Up until the 1980s the electricity market in Germany was a mixture of private interests and municipal providers. The large private providers generated around 80 per cent of electricity, owned most of the long-distance high-voltage transmission grids, and distributed about 70 per cent to the end consumer (Wollmann et al. 2010c). The municipalities, mainly through S*tadtwerke*, retained ownership of the 'last-mile' of the grid – the short-distance distribution networks that connect to the end-consumer.

Liberalisation of energy markets at the European level (driven by directive 96/92/EC) took place in the late 1990s, introducing the right to switch supplier and encouraging the break-up of the monopolies of the German multi-sector *Stadtwerke* (Hall et al. 2016). While the aim was to introduce competition into the national energy market the regulations have in fact led to a wave of mergers and buyouts creating a large oligopoly of the 'Big Four' – RWE, EnBW, E.ON and Vattenfall – which together have a 67 per cent share of the power market in both Germany and Austria (Appunn and Russell 2015). While the Big Four, similar to their UK counterparts, have shifted towards the vertical integration of generation and transmission within their single-sector competencies they have largely retained their historic territorial biases. E.ON owns and maintains grids in the north, west and southern Bavaria; RWE has a strong presence in the industrial Rhine-Ruhr region; EnBW controls Baden-Wurttemberg in the south-west and Vattenfall – itself part-owned by the Swedish state – controls the former east German Democratic Republic (Schlandt 2015a).

The Big Four have faced threats from the two-phased German *Energiewende* – the switch off of nuclear power following the 2011 Fukushima disaster coupled with a huge investment in renewable and decentralised energy. The German government reacted to the 2011 incident by shutting down eight of the country's 17 nuclear plants with the rest due to come offline by 2022 – the majority of which are owned by the Big Four. All four companies are involved in on-going legal proceedings against the German government over the closures.

For telecommunications, the attempt to introduce competition between players has led to state unbundling of services and the opening up of infrastructural networks, yet many of the large companies have again undertaken vertical integration within their sector and many offer joint packages for mobile, landline and broadband. The large companies include Vodafone Deutschland with 33.3 per cent market share, Deutsche Telekom AG (itself part-owned by the German state) with 32.2 per cent, E-Plus (a mobile unit of KPN) with 18.6 per cent and O2 with 15.5 per cent (US Department of Commerce 2011). Similar to electricity, while the sector was liberalised in 1998 with the full unbundling of access lines made available from the state-owned Deutsche Telekom, providers still maintain a largely geographic focus – in 2003 there were 80 city-based carriers (Elixmann, Schwab and Stappen 2003). The liberalization of the telecommunications sector has been incremental. Deutsche Telecom was made into a form of public corporation in 1995, 25 per cent privatized in 1996 and was majority privatized in 2001 (Thatcher 2007).

Since the turn of the century Germany has been reversing its outsourcing policies with a major expansion in the direct municipal provision of public services. Between 2007 and 2012, 60 new *Stadtwerke* were created under a growing culture of re-municipalisation while more than 190 contracts for energy networks were returned to the public sector (Hall, Lobina and Terhorst 2013).

Today some 850 *Stadtwerke* hold half of the retail energy market. In 2013 they had combined sales of 110 billion euros and their market share for Germany retail energy was 46 per cent in electricity, 59 per cent in gas and 65 per cent in heat distribution (Schlandt 2015b). In comparison RWE, the biggest energy retailer in Germany, had a market share of just 10 per cent in gas and 16 per cent in electricity. The S*tadtwerke* are popular and trusted by German consumers. Most are still small enough to act quickly to tailor national legislation to their own local and regional histories. Following the *Energiewende* announcement – the *Stadtwerke* hold almost no nuclear stakes – the president of the VKU (the *Verband Kommunaler Unternehmen*, the German Association of Local Utilities) said the *Stadtwerke* would invest an additional six billion euros in energy by 2020 and double their electricity generation (Schlandt 2015b).

According to Wollman (2010b) the deregulation changes have forced *Stadtwerke* to adapt and integrate some of their services to compete with the national players. While liberalisation may have led to an unbundling at a national level, for the municipalities attempts have been made to 'double-down' on their own offerings in order to compete with the national players. Not only have many areas created new transmission grid operation companies to "economize, pool capacities and join forces" (Wollmann et al. 2010b: 178), they have also established shared services (billing, call centres, book-keeping), built their own power plants to compete in energy production, and are taking advantage of existing horizontal networks to create joint offices with other municipalities to buy energy collectively on the European Energy Exchange (EEX). These changes have been largely successful and the S*tadtwerke* are constantly seen as trusted and competent by citizens. Many have a high retention rate from customers. While the strengthening of local provision has seen growth in renewable energy (co-generation CHP plants constitute 80 per cent of local municipal generation) it is also seen as providing competition and preventing the Big Four from dominating and preventing a national oligopoly. As Wollmann et al outline:

> "… the stage appears to be set for local government and its energy companies to reposition themselves on the energy market and embark upon the 'remunicipalization' (*Rekommunalisierun*) of energy provision… This trend is being fostered by a new 'coalition' between the European Commission, federal and Lander governments, and local authorities to reinforce the engagement of local authorities and their *Stadtwerke* in energy provision with the aim of competition vis-à-vis the market dominance of the 'Big Four' and to safeguard the *Stadtwerke* generation of alternative energy, especially CHP, where they have proved to be champions" (Wollmann et al. 2010b: 179).

Many communities have been bringing other services back in-house such as waste management, housing and public transport. The cultural shift away from privatisation and outsourcing is evident in the fact that today less than three per cent of municipalities are considering privatisation of their existing services. Indeed, the "post-liberalisation dilution of municipal equity in *Stadtwerke* is being reversed" (Hall et al. 2016: 52). There have been attempts to reverse this process in the 21st century with a wave of re-municipalisation (such as to the Berlin water supply). Yet European law still prevents local authorities from going back to the cross-subsidisation policies for infrastructures. Markets must remain open for competitors and consumers still retain the right to choose their own supplier. Despite this, many municipalities have been "through the NPM mill" (Dreyfus et al. 2010) and wish to bring services back in-house, partly for cost savings (public enterprises pay no VAT and some studies have indicated that public firms can deliver the services for up to a third less (Dreyfus

et al. 2010)), but also to create local job opportunities by capturing some of the market, particular in energy, waste management and telecommunications.

While the water and wastewater industry are a mix of public and private organisations, the two remain core duties of public services and remain within the competencies of the municipalities or other public corporations (DVGW 2015). However, with each municipality responsible for its own water service provision there has been "extreme fragmentation" in German provision (Citroni 2010). There are around 6,500 operators in water supply and 6,700 in sewage disposal. Planning and construction activities are often awarded to the private sector making the water industry one of the largest private sector customers. Fees and charges are determined by the state and "drinking water is usually, and wastewater disposal is always, the responsibility of the municipalities" (Citroni 2010: 18). While the supply can be contracted out to private companies acting at arms-length, usually the shares of these companies are owned by the municipalities. In 2010 there were around 6,065 water supply enterprises and utilities, mostly small ancillary or owner-operated municipal utilities. The sector has high levels of customer satisfaction (80 per cent of customers say they are extremely satisfied or satisfied) and 70 per cent of sewers are less than 50 years old (Citroni 2010).

### 4.3.4 SUMMARY

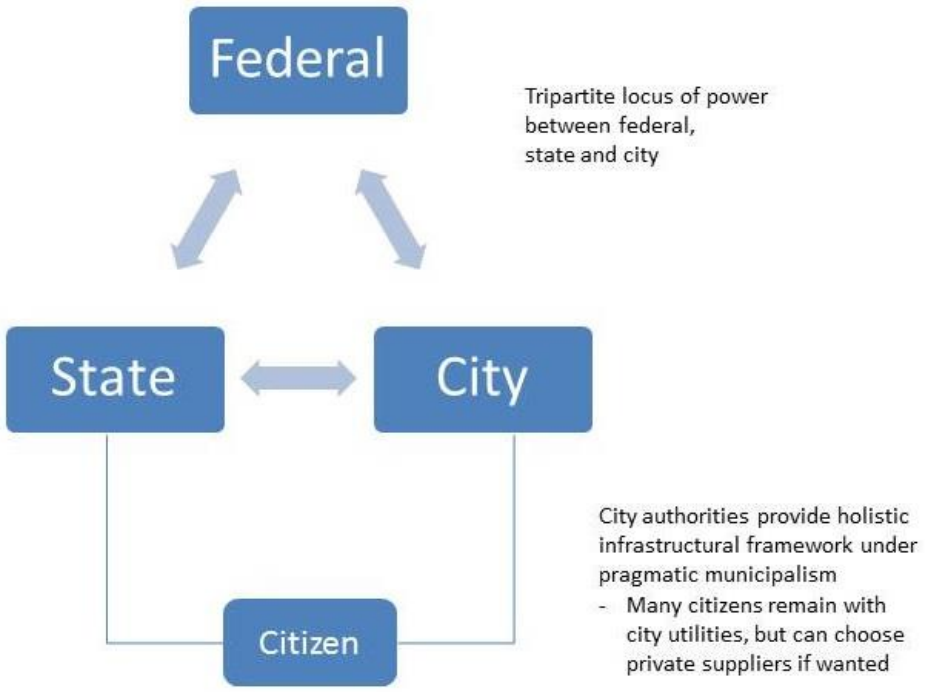


**FIGURE 4-5 THE GERMAN STATE**

The governance structure of Germany operates as a tripartite locus of power between the federal, state and city governments and is graphically represented in Figure 4.5. Germany's form of

pragmatic municipalism sees the state as a valid competitor to private utility suppliers. Infrastructures owned by city authorities are viable, cross-subsidisation between certain infrastructures is possible (subject to European liberalisation laws) and the local public sector offers alid competition to national and international service providers. Many *Stadtwerke* organisations are popular with citizens and, alongside infrastructural provision, can be used for economic development purposes. Integration within Germany is possible and likely in a number of urban regions. However, policy change in Germany at the national level can be slow and piecemeal and new technological innovations may be difficult to introduce into the publicly-managed utilities. The concept of co-determination, the desire to allow forms of direct democracy (many cities allow for referenda to be held on infrastructural decisions) and the aim of inclusive government can act to reduce the likelihood of any radical shifts in infrastructural management techniques.

## 4.4 DISCUSSION

In this chapter, I have outlined the institutional differences that affect infrastructural governance in the US, the UK and Germany and outlined how they may affect the potential for integration. Key to this is a recognition that each country has its own socio-political history and culture, its own institutional structuring framework, and varying desires and abilities to adopt policies that may foster infrastructure integration. In summary, the US operates with a weak federal government forced to adopt carrot and stick approaches of finance and regulations to promote its policies to the state and city levels of government. The UK, in contrast, has a strong central government able to quickly promote more market-friendly and profit-driven policies, often against the will of the local arm of government. In Germany, the emphasis is on cooperation, coordination and partnership across the vertical areas of governance (federal, state, local) and the horizontal levels between business, unions and third parties, offering infrastructure integration as a key tool for cities as part of pragmatic municipalism policies. From this above review of institutional structures, and by utilising the conceptual framework adopted in Chapter 2, we can estimate the likelihood of various forms of infrastructure integration to occur. There are four points to make.

First, the federalised nature of the United States and Germany does allow for cities to have a degree of autonomy over infrastructural matters that is absent within the UK. The PUC model practised within the US, and the proliferation of *Stadtwerke* organisations within Germany, allows for the governance of infrastructure networks to be more localised than in the centralised UK state. As such, if integration is wanted by policy makers or planners within cities in the US or Germany, they will be more able to push policies through than in the UK, which relies on a national governance model. Yet there are key differences between the US and Germany. In the US, the sectoral divisions between many infrastructures remain regulatory, and any forms of organisational integration (such as creating organisations to manage more than one infrastructure) may be difficult. The PUC model appears to ‘splinter’ infrastructures at a regulatory level, regardless of the federalised nature of the state. This makes it difficult to create forms of sectoral integration, and as such networks may remain loosely coupled to each other. The *Stadtwerke* model, meanwhile, does to some degree allow for sectoral integration to take place, which may facilitate a more tightly coupled degree of integration than will be possible elsewhere.

Second, the *speed* of any potential moves towards infrastructure integration will vary within the three countries. The UK has a history of quick and radical shifts in policy that can be enacted often against the will of the local arm of state. If the national government chooses to move towards a reintegration of its currently splintered infrastructural sectors, then this policy may be carried out more swiftly than elsewhere. However, no government since the 1980s has sought to integrate infrastructures on a national scale. Instead, it is likely that infrastructural management will remain siloed and market-based. In the US and in Germany, the slow pace of change within governance networks created by the fragmented federal structures could filter through to attempts to introduce innovations within infrastructures when they arise or are needed. The opposition to Reaganite reforms in telecommunications within many US states is a good example. However, these potential problems may be offset by the power locus set within the state-level governance structure. A highly educated, professionalised, career-driven civic structure could offer experts influence over future utilities without the threat of external political influence. The decentralised decision-making structure allows for innovative cities to act quickly within their own locales without seeking prior approval from the federal centre. In the US especially, the desire to integrate on a geographic level (through telecommunications, road and rail networks) has been a common discourse since the country's creation. However, the patchwork quilt of policy amongst states and the relatively weak federal centre in both the US and Germany makes it difficult for any meaningful integration to occur on a national scale. When infrastructure integration does occur, it may often be local, small-scale and sector-specific.

Third, there is significant variation on the *likelihood* of infrastructure integration to occur. Within the UK the emphasis on consumer experience over resource reduction, on competitive markets over state guarantees, and a focus on sectoral efficiency over holistic territorial planning makes it unlikely that any radical shifts towards infrastructure integration will occur. The UK has an added complication in being splintered at the national regulatory level: the government regulator Ofcom regulates the telecommunications industry, Ofgem regulates energy, Ofwat regulates water etc. Without significant changes within central government and without infrastructure integration being pursued as a specific and clearly defined government policy it is difficult to see how significant forms of integration can occur. The German and US conceptions of the state – German co-determination and US weak federalism – allow for infrastructures to be managed more at the urban scale than in the UK, allowing locally tailored and context specific networks to be developed at the expense of national goals of universalism. Cities can, and do, pick from a rich tapestry of governance models to tailor to their own needs, from public or private regulated monopoly provision to free competitive markets. In Germany, the emphasis on the local has allowed for a re-municipalisation of a variety of urban infrastructure services, offering a vehicle through which integration may be pursued as a specific policy goal at the local level.

Fourth, there is variety in the *forms* of infrastructure integration that are likely to occur within the three countries. The US and the UK are more likely to undergo vertical sectoral forms of infrastructure integration (coming with a history of sectoral infrastructural management policies) as opposed to the multi-sector provision as practised in Germany. Despite the PUC model in the US providing a possible organisational vehicle for multi-utility governance, many infrastructures in the country remain splintered and sector-specific: water, energy and telecommunications utilities are separately owned and managed under strict regulatory controls. A similar situation exists in the UK. In contrast, Germany offers an example of how sectoral integration between sectors may be

possible. The *Stadtwerke* organisations are similar to the US PUCs, however they have the ability to offer direct provision of services and can act alongside city authorities in terms of economic development and social service provision. The *Stadtwerke* model offers an example of how organisational forms of integration could occur.

The next chapter sees the start of the empirical stage of this research, and I begin with an examination of Seattle.

# 5 SEATTLE: THE EVOLUTIONARY CITY

As discussed in Chapter 4, responsibility for power over infrastructural concerns within the United States lies at the city and state level, with a weak federal centre unable to force contentious policy goals onto unwilling states and cities. The opposition from many states to Reaganite reforms in the telecommunications sector is a good example. This decentralised decision-making structure allows cities to maintain a degree of autonomy over infrastructural management, while the professionalised civil service can allow for long-term decisions to be taken by knowledgeable technicians rather than politicians seeking short-term impacts (Clingermayer and Feiock 2001). However, the slow pace of change within governance networks created by the fragmented federal structure may filter through to attempts to introduce innovations within infrastructures when they arise or are needed, while the sectoral governance model may make it difficult for infrastructures to be jointly managed under one roof, unlike the territorial model practiced in many continental European countries.

Despite these concerns, Seattle was chosen as a case study for this research as it has a reputation for proactive innovation in infrastructure. The city receives around 90 per cent of its power from clean hydroelectric power plants fed by nearby mountain glaciers (Fullerton Jr et al. 2012). It has a city-owned energy and water utility enthused with what appears to be a strong public ethos and a commitment to provide affordable and high-quality services to its citizens (Rice 2010). Its economy is dominated by global high-tech companies such as Amazon, Microsoft and Boeing. Yet the argument in this chapter is that, despite these advantages, infrastructural management in Seattle is often siloed, with regulations, culture and political actors working to prevent aspects of infrastructure integration.

This chapter is split into three sections. It begins with an examination of the institutional context of Seattle, looking at the management of the city's infrastructure networks and exploring how the city has become an exemplar for clean urban living. Second, the chapter explores the perceptions of what infrastructure integration might entail from key actors responsible for infrastructural management: their perceptions on what integration is, what allows it, and what constrains it. Third, I outline three issues that impact on the success of infrastructure integration within the city: the strict accountancy laws within Washington State that makes aspects of infrastructure integration difficult; the political machinations of key actors involved in infrastructural management that make integration unwanted; and forms of direct democracy which offers an arena for citizens to influence infrastructural developments. The chapter ends with a discussion of what I argue is Seattle's *evolutionary* form of infrastructure integration.

## 5.1 SEATTLE'S INSTITUTIONAL FRAMEWORK

Seattle is located in the state of Washington in the north west of the United States, straddling the Puget Sound inlet to the Pacific Ocean to the west and Lake Washington to the east (Figure 5.1). The founding of the city dates to 1851 and it lies about 100 miles south of the Canadian border. The city

is home to the eighth largest port in the US and is an economic hub for trade, tourism and technology (Fullerton Jr et al. 2012). The city is nicknamed the Emerald City and has sought to position itself as one of the most sustainable cities in the world (Sanders 2010). The wider region is often referred to as "Cascadia, the Great Northwest, the Great Raincoast, God's Country, the Promised Land, and Ecotopia" (Karvonen 2010: 156) or, as one interviewee said, Seattle is the "Emerald City of Emerald Cities" (interview, University of Washington academic). In 2006 city promoters added another tagline of "Metronatural" to refer to the city's location in a pristine and picturesque landscape while being in harmony with nature (Karvonen 2010).

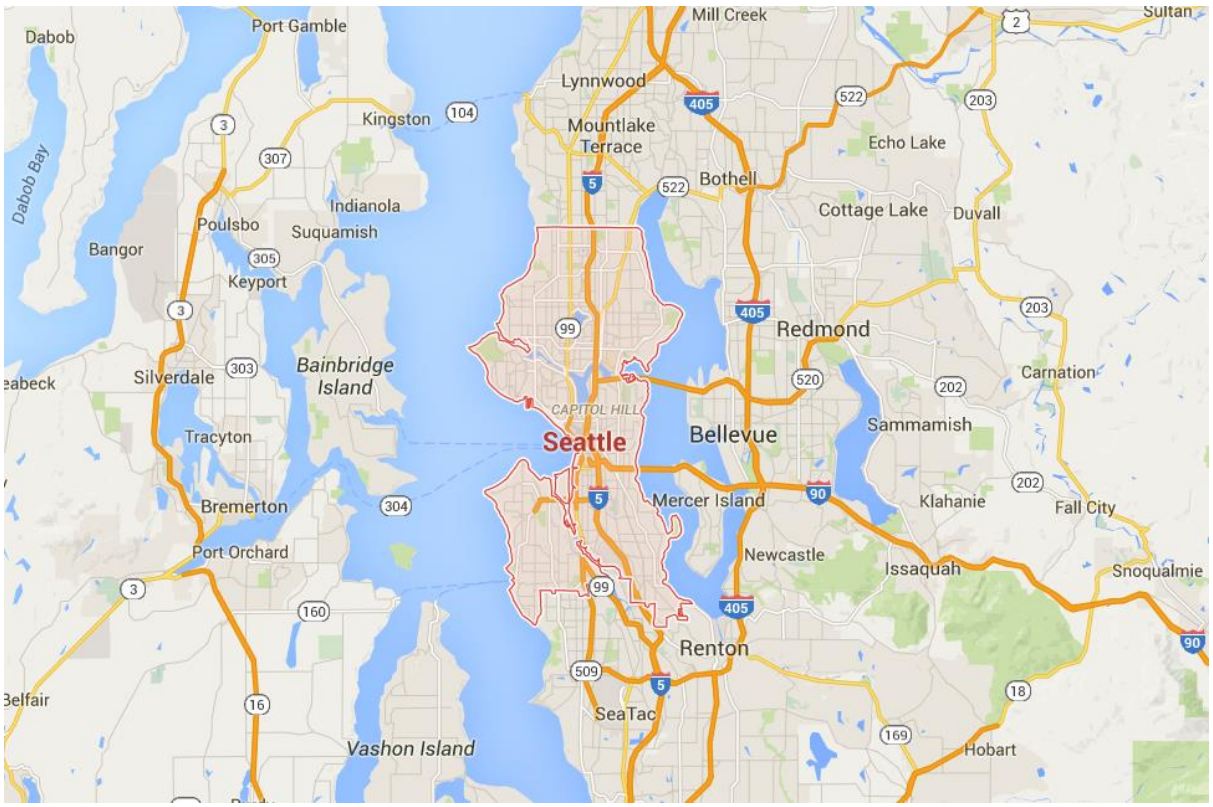


**FIGURE 5-1 THE CITY OF SEATTLE**

Research for this project is focused on the City of Seattle, which is responsible for all legislation relating to the city's electricity, water, solid waste and drainage facilities, as well as maintaining the city's police and fire departments, parks and libraries. The City of Seattle is the largest city within King County, one of 39 administrative counties within the state of Washington. Seattle has a population of over 650,000 people and growth of 3 per cent in 2014 made it the fastest growing city in the United States (Balk 2014). More than half of the city's population live in the central metropolitan area, which is expected to grow by more than 32 per cent between 2005 and 2030 (Hutyra et al. 2011). As one interviewee said, "Seattle is just on fire… you've got 100,000 more people here in ten years, with a lot of high-tech workers" (interview, University of Washington academic).

Seattle is the county seat of King County. The wider metropolitan regional area is made up of King County, Snohomish County to the north and Pierce County to the south. In 2015 this metropolitan

area (which includes the cities of Tacoma and Bellevue) had a population of around 3.7 million people (Census Reporter 2017). Beyond this exists the Puget Sound Regional Council (PSRC) which includes the three counties within the Seattle metropolitan area and Kitsap County to the west. The PSRC acts as the Metropolitan Planning Organisation and is responsible for long-term transportation planning, economic development and growth management in the region surrounding the Puget Sound. The PSRC provides a forum for cities, towns, state agencies and transit authorities to discuss issues and develop regional policies for its constituent members to pursue (PSRC 2017). Mercier et al (2016) found that the diversity of actors involved within the governance structure leads to political consensus seeking, and while some actors viewed the governance arrangements as "disjointed" the researchers found that Seattle offers a "true equilibrium between the contributions of the different levels of government" and the "State government of Washington is seen as helping, not hindering policies" (Mercier et al. 2016: 99).

Seattle has a strong Mayor-Council form of city governance. The Mayor and City Council members are elected at large by the entire city, rather than by geographic district, and in 2015 the council was comprised of eight Democratic councillors and one Socialist Alternative councillor. The Mayor is elected in a non-partisan election and the system is modelled on the US federal government with a separation of the executive (mayor) and legislative branches (council) of government (Lavery 1992). The Mayor is the chief executive officer of Seattle and is wholly responsible for administration. While he can hire and fire the heads of departments, responsibility for policy-making is shared with the city council, although the Mayor can veto ordinances (which can then be overridden with a two-thirds council vote). Essentially, power in Seattle lies with the Mayor (Lavery 1992). While this system has its advantages it has been criticised for embodying too much centralisation and one researcher found that the "mass of personnel and financial rules and regulations tended to smother initiative and led to frustration" amongst service directors: this centralisation can make it difficult for "managers to manage" (Lavery 1992: 12).

Politically, Seattle features a largely Democratic-voting urban population within the city limits, contrasted with a more conservative, suburban and Republican-voting commuter belt in neighbouring counties (interview, City of Seattle director). As one interviewee said, "you've got to go to a museum to see a Republican in this town" (interview, University of Washington academic). The city has moved to increase the minimum wage to $15 an hour (McGreal 2014), more than twice the amount mandated by the federal government, and it has one of the highest percentages of citizens with university degrees (Modarres and Dierwechter 2015).

Economically the city has enjoyed major success in recent years, following a downturn in the 1970s and 1980s as the former economic base contracted. When Boeing cut thousands of jobs in the 1970s the city became infamous from an emblematic sign placed near the airport by two realtors: "will the last person leaving Seattle turn out the lights" (McGreal 2014). Yet today unemployment is low: the rate has remained under 5 per cent since January 2013. Seattle has been successful in attracting a range of high-tech industries and a highly educated workforce (Herrschel 2013). The region is a key manufacturing centre for Boeing and is home to the US headquarters of Amazon, Microsoft, Nintendo and Starbucks. Amazon alone has created 14,000 jobs over the last decade and is helping to expand the city's downtown northward with the creation of up to 50,000 further jobs (Soper 2016). Amazon could soon cover 10 million square feet in the city or 25 per cent of the total premium office space in downtown Seattle (Soper 2016). This growth has the potential to create

problems for the city's transportation infrastructures and voters have raised concerns over increasing traffic, rising housing costs and income inequality (interview, University of Washington academic). Alongside the large number of technology companies Seattle has sought to expand economic sectors in biotechnology, chemicals, electronics, instruments, and software (Sommers et al. 2000).

The ownership and management of Seattle's infrastructure networks are summarised in Table 5.1. Most networks within the city are governed as city-owned sectoral monopolies. Seattle City Light (the city's energy utility) and Seattle Public Utilities (SPU, which provides water, sewage, drainage and garbage services) are both wholly owned by the City of Seattle. SPU owns two major drinking water treatment facilities (operated and maintained by private contractors) and provides drinking water to neighbouring communities. It also operates the city's engineering services department. King County acts as the public transit authority and operates light rail lines and bus routes within Seattle. It also manages the Seattle Streetcar lines, although they remain owned by the City of Seattle. Hydroelectric power provides 88.9 per cent of the city's energy and, because of the low operating costs of hydroelectric power generation, Washington's average retail electricity prices are the lowest in the nation (US Energy Information Adminstration 2015).

One infrastructure sector which is not directly controlled by the city government is telecommunications. Three private companies operate within the city limits – Comcast, CenturyLink and Wave – however there have been complaints over service quality and sporadic residential access (Cetron 2015). Seattle's Office of Cable Communications governs the three cable and broadband providers through regulated market competition. There have been on-going discussions surrounding the potential to create a city-owned broadband provider to utilise the 500 miles of 'dark fibre' (unused) that exists under Seattle's streets. The fibre was rolled out incrementally during the 1990s high-tech boom which remains "a monument to the bold aspirations of late 20th century high-tech dreamers" (Washington Policy Center 2014). Several public-private partnerships to put the unused fibre to use have so far been unsuccessful (largely due to cost) and numerous studies have explored the possibility of the city running its own broadband network (Cetron 2015).

The City of Seattle finances and plans its infrastructure projects through a rolling six-year centralised Capital Improvement Plan (CIP) which outlines anticipated investments by City Light, SPU, the Department of Transportation and other major city departments such as Parks and Recreation, the Department of Information Technology and the Seattle Center. The 2016 to 2021 plan directs spending worth more than $6 billion, with 635 individual projects expected to be funded. 59 per cent of these funds relate to utility spending on energy and water projects. The CIP is drawn up in relation to the City of Seattle Comprehensive Plan, a 20-year roadmap for Seattle's growth. As the city outlines:

> "The plan guides City decisions on where to build new jobs and houses, how to improve our transportation system, and where to make capital investments such as utilities, sidewalks, and libraries. The Plan is the framework for most of Seattle's big-picture decisions on how to grow while preserving and improving our neighborhoods" (Seattle City Budget Office 2016: 14).

| | Water | Sewage | Waste | Drainage | Heating | Energy | Transport | Telecommunications |
|---|---|---|---|---|---|---|---|---|
| **Main Actors** | Seattle Public Utilities | | | | Seattle Steam Company | Seattle City Light | Seattle City Council.<br><br>King County Metro. | Comcast<br>Wave<br>Centurylink |
| **Comments** | City-owned utility company. SPU was created in late 1990s with the merger of four separate entities. Main aim was to integrate the shared engineering and front-office functions.<br><br>Water utility remains a single-purpose Enterprise fund. | | | | Small provider with 18 miles of steam pipeline. Serves 175 city businesses. Half of homes in Washington state are heated with electricity | Publicly-owned monopoly, regulated by Seattle City Council | Light rail and bus routes managed by County government. City parking, cycle and pathways managed by the city. | Seattle's Office of Cable Communications regulates the three cable and broadband providers through market competition. |
| **Other Actors** | SPU manages its own refuse collection. Private collection companies operate in the surrounding King County. | | | | | Puget Sound Energy. Investor-owned regulated monopoly supplying 1.1 million customers | | Preliminary talks about creating a city-owned broadband provider. |
| **Principles** | • Publicly-owned sectoral monopolies for most infrastructures, regulated market competition for telecommunications.<br>• Strong public ethos with subsidies for the poor and the aim of universal service provision.<br>• Infrastructure governance restricted by state accountancy rules: energy and water utilities must remain separate entities.<br>• Strong judicial oversight to prevent state overreach and cross-subsidisation between sectors. | | | | | | | |

**TABLE 5-1 THE MANAGEMENT OF SEATTLE'S INFRASTRUCTURES**

## 5.2 Interviewee Perceptions of Infrastructure Integration

During the interviews for this research all respondents were first asked to offer their opinion on what the concept of infrastructure integration meant to them. The aim was to explore the definitions surrounding the term before discussing the issues which may impact upon it. Their responses are explored in this section. One respondent discussed the capacity of Seattle to innovate not just technologically but also in terms of governance, agreeing with my initial suggestion that if infrastructure integration were to occur anywhere, Seattle would be a favourable context:

> "…gee it's not only Seattle, the Emerald City of Emerald Cities, but it's got all these advantages: it's chocked full of high-tech energy sectors and players, tonnes of innovation, a very, very well resourced research complex around the University of Washington in Seattle with tremendous spin off potential and innovation potential, and yet…" (interview, University of Washington academic).

In Seattle, the discussion of infrastructure integration offered by interviewees can be grouped into three main themes: the opportunities to provide social equity and to meet climate goals through various forms of infrastructure integration, the benefits of information sharing between departments through low-level forms of organisational integration, and conversely, the benefits associated with maintaining the existing organisationally splintered networks. I will examine each of these three themes in turn.

### 5.2.1 Sustainable Infrastructure Management

When asked to define infrastructure integration one respondent discussed the importance of the city authorities being able to use infrastructures to address social issues, rather than a desire to see the joint governance of infrastructural networks:

> "So integration… I would say the immediate instinct would be social inclusion programmes, equity concerns, inaccessibility to key services, the fairness question about how we charge… average rate costing for services, which is essentially subsidising suburbanites over city dwellers, those kinds of issues, as opposed to kind of joined up" (University of Washington academic).

The interviewee cited the city's Utility Discount Program as an example of this form of social provision, which can lower a customer's energy bill by 60 per cent and bills to SPU by 50 per cent. More than 18,000 utility customers are enrolled within the scheme and in 2016 this was extended by auto-enrolling another 5,000 customers living in city-subsidised apartments (Jolly 2016). While the creation and expansion of these schemes are largely political decisions the response from an interviewee within Seattle City Light demonstrates the public ethos and desire for universal provision that exists within the organisation: "we're more than glad to do it, if it's what the city wants" (interview, City Light executive). This reinforces the evidence presented by other researchers that officials within Seattle view government as not merely an enabler of private sector innovation

but also as a proactive societal actor that can provide a key role in ensuring social equity alongside "service innovation and integration, interactive service, and service of high quality" (Alawadhi and Scholl 2013: 1698). For example, many of the Reaganite privatisation policies enacted by the federal government in the 1980s and 1990s, such as the changes to the telecommunications industry, have largely been ignored by Seattle politicians who view the city as a key actor within a mixed economy. In Seattle, the public sector has a key role in service delivery. Another example includes Seattle's smart city projects, as 22 out of 24 projects relate to the city government and how it provides services (Alawadhi and Scholl 2013: 1698), suggesting a desire to improve the delivery of infrastructures and the interfaces between the city and citizens.

Another respondent, when asked to define infrastructure integration, discussed the benefits of integrating geographically with neighbouring jurisdictions:

> "I think there are two standards of integration, one is integration across lines of business, and the other is integration across governmental jurisdictions. And I think there are different approaches… each one of them is a different way of looking at things. We've done some areas. We are very well integrated across jurisdictions, particularly the Metropolitan sewage system, and that's 40 governmental jurisdictions that participated in that. And that I think is a good example of integration" (interview, former city councillor).

However, forms of geographic integration may prove problematic due to a fear of political interference from neighbouring authorities who view the City of Seattle with suspicion and who may be reluctant to engage in infrastructural partnership agreements. One interviewee said:

> "… there is a sense that Seattle is the 900lb gorilla and unless we try to tie this monster down, we just can't deal with it. He just comes in and beats up on us, so the adjoining counties are quite reluctant to allow King County Council, even with consultation, to take over running the trains into their county" (interview, Seattle-based engineering and environmental consultant).

One example of how these fears may be realised can be seen in transport policy, as Seattle's consensus-based approach to policy making:

> "…leads to the adoption of plans that represent the lowest-common de-nominator. For example, the Mayor of Seattle voted against the 2010 long-range transport plan on the basis that it did not meet the regional objectives on transit, land use, social equity and GHG emissions reduction" (Mercier et al. 2016: 99).

Seattle has sought to demonstrate leadership globally on how to respond to climate change threats and to pressure the federal government to act on environmental policies, which may lead to fears amongst neighbouring authorities that they will be forced to align their own policies with the central Seattle authority if forms of geographic integration take place (interview, Seattle-based engineering and environmental consultant). Rice (2010) argues that Seattle has worked to integrate concerns over climate change into the mundane daily workings of each city department and since the 1992 Rio summit officials have sought to incorporate mitigation efforts into every aspect of urban design. Projects intended to reduce the city's carbon footprint, to develop new technologies under an ecological modernist paradigm, and to mitigate the impacts of climate change have had an impact on governance within the city and the city's interactions with its residents. New carbon projects

have allowed Seattle's governance regime to "reaffirm and rearticulate local government capacity in a variety of areas" (Rice 2010: 933) while providing the city authorities with opportunities to regulate key infrastructural aspects of the urban area, from transportation developments to social and economic practices. For example, in 2000 the city council passed a resolution ensuring that all new construction and remodelling projects over 5,000 square feet should meet a LEED Silver rating. This policy was the first of its kind in the US and in 2011 it was updated and mandated that new and remodelled projects should meet the Gold rating. The city has been able to assert its authority and regulate "infrastructural design, commercial activities, and neighbourhood development through formal and informal regulatory means that act directly on the city's citizens and enrol them in the process of mitigation" (Rice 2010: 932).

While Seattle's sustainability goals – combining social equity concerns with attempts to meet climate goals – may lead to the 're-articulation' of government capacity within the city of Seattle (Rice 2010), it does appear to work against forms of geographical integration amongst neighbouring authorities reluctant to have a '900lb gorilla' involved in infrastructural partnership agreements.

### 5.2.2 Organisational Integration

The second theme of infrastructure integration that emerged from the interviews relates to importance of information sharing between city departments and between organisations involved in infrastructure management. One interviewee said the Capital Improvement Plan (CIP) and the Comprehensive Plan are examples of good integrated working practices:

> "…when I look at how we are integrated with other departments, probably one of the biggest things we have is the Capital Improvement Committee that goes across all departments, and so when we go out and we need to do some infrastructure on a street, tear it up, what have the other departments planned on that street? So we try and go in and take everything at once, and leverage everybody's work, so we don't go in and restore a street, and a year later somebody is tearing it up and restoring it again" (interview, City of Seattle director).

There is recognition within Seattle that further forms of infrastructure integration could be beneficial in theory, however the director highlights the difficulties in practice:

> "We find a lot that different departments aren't talking to each other, so even though it's been lately kind of informal we just get together and try to assess the impacts of these telecommunications developments across departments, I think there has been more of a push to formalise that interdepartmental approach. We need that kind of communication" (City of Seattle director).

The department director sees information sharing between departments and utilities to facilitate a coordination of engineering work as a benefit. However, another benefit of the CIP is the manoeuvrability it offers to technicians to develop plans and projects without disruptive high-level political interference. Once the city council has approved the initial six-year plan it is difficult for individual projects to be re-opened and funds to be shifted from one project to another. One

respondent from City Light said politicians often seek short-term projects with short-term impacts, adding:

> "We have got projects that are laid out in the plan, and even though that the rates are approved every two years, the rate path has been approved by the council, so that helps the long term, and it's definitely going to help us going forward but before that there would be… you go to the council every year at budget time, and they would look at your budget, and you didn't know what was going to happen with it" (interview, City Light executive).

While it is perhaps wrong to claim that the CIP is intentionally designed to protect infrastructural governance from political interference, one of the consequences of its design has been to lessen political input over project management and it has led to a shift away from focusing on short-term electoral goals to more long-term operational thinking. One respondent said:

> "Far be it from me to question what the council and the Mayor does: the people elect them and that's how it operates. But we are trying to figure out… is there some way we can get around that and be able to do this. One of the things is for us to be getting further ahead in our planning so that we are better prepared, so that we better know what it is that we need to do and can sort of shrink the amount of time. I would say it's not an ideal situation, because the reality is that, by the nature of politics, as much as they want to be thinking long term, in some ways they have to kind of think about their short term political aspirations and things like that, you know, it would be naïve to think that those don't sometimes conflict with each other. In an ideal world, you would have an operating board that would make these decisions and they would be thinking like a utility should be, out 50, 60 years, what do we need to do? Again, it's the yin and the yang, we have publicly-owned, which sounds like it's a great deal, and I would say it is very good, but one of the downsides is this aspect of it. You never get everything. It's rare that you get to hit a home run" (interview, SPU executive).

While the CIP is advantageous for technicians in excluding political intervention from operational concerns, it can also act as a visionary blueprint for other departments and utilities, able to schedule their own projects against the centrally-held masterplan. The rolling nature of the programmes allows departments to continuously input their updated GIS models into the central database, choosing which projects to prioritise depending on the activities of other departments. While this may add a layer of bureaucracy that can slow down the engineering process, one respondent said:

> "…if each department has kind of a business plan and asset management strategy, then you can look at them together and figure out 'ok, where are the opportunities', if each of the lines of business has a plan for how they want to move forward and make investment decisions, then you can overlay them and start to look for where the opportunities are to work together, to make improvements, and to minimise the impacts to the citizen or the business out on the street" (interview, transportation executive).

Another said:

> "In a perfect world, what you do is say I'm going to plug my five-year capital plan into a GIS layer, the utility company, you guys plug yours in, and on and on and on and everybody plugs that stuff

in… we meet about twice a year to look at that long-range activity and I think… we want to meet like once a month" (interview, City of Seattle director).

This type of low level integration (based around information sharing) is made easier by the public ownership of the city's main utilities ("if one of them was private they probably couldn't do that", interview, former city councillor). However, this can lead to perverse incentives with departments being protective of their own budgets. One example involves departments delaying their own work until they are confident another department will pay for any remedial action. City Light is the largest city department in terms of funding and employees, and other departments appear to be willing to wait until City Light is funding engineering works before they themselves go in and undertake their own projects, leaving City Light to fund the excavation and street repairs. One interviewee said:

"The City of Seattle hasn't spent a dollar in the last 20 years on fixing a non-arterial street, so seriously… when there are sewer spot repairs, and water line spot repairs needed, and the utilities have to dig down and replace those spot repairs, they have to put in a brand new concrete panel on the street, so… that's kind of the long term side street replacement strategy… we're just kind of, honestly, running those to failure right now. Although, we're about to go out for our new levy, and we have a new mayor, and that mayor appears to want to spend a certain amount of money on non-arterials, but this will be the first time in 20 years" (interview, transportation official).

Many respondents highlighted the need for Seattle city authorities to act as an organisational leader in setting the future direction of infrastructures, around which other organisations can align their own projects and visions. Within Seattle most of this visionary thinking is led by politicians – partly due to the centralised power structure – who focus on high-level policies and leave the mundane tasks of implementation to officials and technicians. Infrastructure integration will be pursued if city authorities mandate it as a policy objective, but otherwise officials are left alone to deal with the day-to-day management of their own domains and to seek whichever structure they see as the most suitable to deliver the necessary services. One example is the creation of a joint customer contact centre for both City Light and SPU (although according to one interviewee "it's been, I would say, a fairly unhappy marriage", interview, retired City of Seattle director). Another example is SPU's Comprehensive Asset Management program, which has involved the integration of key functions within the utility (Binney 2012). Utility managers have been flown in from Australia to advise SPU workers as part of a staff exchange program. Key to the approach is a focus on financial, environmental and social factors – known as the "Triple Bottom Line" approach towards sustainability. The program is used to schedule and respond to potential and actual breakdowns in order to not disrupt services to customers by assessing the networks and assets on a regular basis. One component of this is the Specifier-Provider model. Specifiers act as organisational leads and are accountable for "proposing service levels, ensuring that the organization meets service levels, negotiating and meeting regulatory requirements, developing business cases for investments, and determining the best balance between capital expenditures and maintenance activities" (Martin 2005: 4). Providers (either teams from within city departments or from external contractors) are then contracted on an as-needed basis to carry out the necessary work.

The integration here involves the various functions of SPU being brought together in order to develop a rolling plan to repair and upgrade assets as and when needed. This offers an example of a

state authority acting in an organisational, visionary role, as envisioned in some aspects of the system of systems approach to infrastructure (see Chapter 2). SPU can take a holistic view of the city and its various infrastructures, act as the visionary lead in deciding where the priorities should lie, and then contract out for the work when required. As SPU reports, the "establishment of service levels and performance indicators requires us to focus externally on customers and internally on our productivity" (Seattle Public Utilties 2004: 89). This type of infrastructure integration has evolved from within SPU as a way to improve performance and assist with operational management. There was no top-down instruction to integrate SPU's functions in this way. It emerged through information exchange with utility managers in Australia and as an attempt to copy best practice. SPU's functions are integrated at the managerial level and service providers are themselves siloed into certain specialised functions, allowing them to become "very good at achieving results in their specific area, and their opinions and perspectives are very valuable to specifiers" (Seattle Public Utilties 2004: 4)

### 5.2.3 Sectoral Independence

The third theme that arose during the interviews was the strong desire from certain officials to retain clear separations between infrastructures and to retain the existing structure of sectoral independence. One respondent raised concerns over what infrastructure integration could mean:

> "Everyone says it's good, but we don't really know what it means. I think it means that… interactions across boundaries are seamless. If everything is kind of integrated it's hard to tell where I stop working and you begin. The dance is so tight that you can't really tell my part from your part" (interview, City of Seattle director).

Another respondent was openly hostile to any suggestion of infrastructure integration and questioned the positive discourse surrounding the term 'integration' in its entirety. The high-ranking energy official, who worked in Germany following the fall of the Berlin Wall in the 1990s, expressed outright hostility to the idea that infrastructure integration is a beneficial and desired concept:

> "I've helped to dismantle tight integration in 1990. We privatised things that were tightly integrated and didn't work, because they were tightly integrated. I hope people will remember what reunification meant and the immense amount of work needed to pull apart this horrible felt mat of everything together, no real accountability, everybody passing the buck, all decisions being made by committee, no free market. The more you centralise, the more you open the door to playing hanky panky with budgets and you don't know where the money is going, you open the door for extended decision-making chains, everybody wants to have a word in there… people do not understand the subject matter, insert all sorts of other topics that are not supposed to be in there, so the more federated, the more at the periphery you can be, the better" (Interview, City Light executive).

## 5.3 Issues Impacting Upon Infrastructure Integration

After an initial discussion on the definitions of infrastructure integration, the interviews moved on to examine the factors that could impact upon its implementation within Seattle. The factors that arose can be grouped into three themes: the constraining regulatory environment of Washington State which makes the integration of infrastructures difficult; the ideologies and activities of key actors involved in infrastructural management which makes it unwanted; and democratic pressures arising from a highly engaged citizenry enthused through forms of democratic participation, which can often take power over infrastructural matters away from city officials. In this section I will examine each of these topics in turn.

### 5.3.1 Judicial Splintering

The first feature that influences infrastructure integration within Seattle is the regulatory structuring environment within Washington State that constrains what the utilities can and cannot fund. Despite SPU and Seattle City Light being publicly owned, the water and energy utilities are legally governed as separate utilities. They are classified under US law as single-use enterprise funds: self-supporting departments funded through charges issued to those who directly benefit from the service. Enterprise funds are common ways to finance water, electricity and gas utilities in the US and are, in theory, useful entities that can help reduce service wastage (i.e. through pay-as-you-go-type charging ensuring those who use the service pay for it) (Molinari and Tyer 2003). One consequence of this is that, within Washington State, enterprise funds can only fund projects relating to their 'core nexus': City Light can only fund energy-related projects; the water utility can only fund water-related projects. The courts in the US are not afraid to rule against state-owned institutions that are seen to breach the state's Accountancy Act, crystallised in the Washington State constitution under Article VII, Section 5:

> "TAXES, HOW LEVIED. No tax shall be levied except in pursuance of law; and every law imposing a tax shall state distinctly the object of the same to which only it shall be applied" (State of Washington Constitution).

Although interpretation of laws and regulations by the courts can be fluid these accountancy laws have segregated the type of projects the utilities can and cannot fund. Interpretations of the accountancy laws by Washington state courts means that energy companies can only pay for projects which have an energy nexus, while water utilities can only fund projects with a water nexus. One interviewee said:

> "We are limited in some ways by state law. State law requires that even if we do something for another city department we have to get paid the cost of doing that. We can't do anything for free. We can't subsidise the city in any way" (interview City Light executive).

While this may be seen to restrict the amount of assistance City Light can offer other city departments the respondent added:

> "…actually, the Public Accountancy Act applies to all city departments. So, as we get services we have to pay for them, as they get services from us, they have to pay us, just like any private company, and it has got to be consistent, which creates some interesting dilemmas, because in other parts of the country the electric utilities have been able to do things and subsidise it with electric revenue" (Interview City Light executive).

The separations created by the accountancy laws were tightened through several court cases from 2000 onwards, led by former city attorney Rud Okeson and three colleagues. One interviewee described the group as "retired, and they were doing it as a public duty… and having a good time at it too I have to say" (interview, environmental consultant). One court case involved the city council transferring responsibility to pay for street lights from Seattle's general fund to all City Light ratepayers. In 2003, the Washington State Supreme Court ruled that this new "tax" was illegal and unconstitutional as "providing streetlights is a governmental function because they operate for the benefit of the general public and not for the comfort and use of individual customers" while "City Light customers have no control over the provision and use of streetlights" (Ammons 2003). Another case in 2008 saw the Washington Supreme Court rule that the maintenance of fire hydrants was a governmental function and costs must be paid out of the city's general fund, rather than through the water utility in SPU. SPU was ordered to refund the city council for the three years it funded the maintenance of fire hydrants (with 12% interest). These cases have tightened the accountancy laws in the state of Washington and created a form of *judicial splintering* – the regulatory and judicial separation of infrastructure sectors within the state. For joint projects involving multiple city departments, such as a multi-billion-dollar redevelopment of Seattle's waterfront viaduct, the utilities can cooperate but detailed records of costs have to be kept. One interviewee said:

> "…what will happen is the costs are segregated, and whatever costs are for the electricity, goes to that, the costs for transportation go to the general fund, the costs for public utilities go to public utilities. There's some opportunity to do a little bit of fudging around that… yeah it's painful, it's definitely painful" (Interview, former city councillor).

While several respondents to this research felt the state accountancy laws acted as clear barriers to infrastructure integration one respondent from City Light highlighted the beneficial aspects of separation:

> "We are a utility. We are trying to provide the lowest cost, most reliable energy for our customers. They pay for it. Why would a utility customer pay for something that they have never bought? They haven't bought parks. Let me take a different example: if I go to a gas station and buy gas, they should finance the local water park? [laughs]. If you want better parks then say you are going to pay more taxes to pay for better parks, or you privatise your parks then you pay through an entrance fee, or… I don't know what the answer is I'm just a lowly utility guy. All I understand is you should not take money that you are paying for one thing and then apply it to something else. That is cheating [laughs]" (interview, City Light executive).

Although City Light cannot fund the maintenance of street lights, officials have found ways to circumnavigate the strict interpretations:

> "… if you have got a problem in your factory, we will go out and consult with you about that problem, we will help you buy a cheaper, more energy efficient fan, or something like that, and so they did allow a certain amount of assistance from City Light to the city on the street lights, but it's really kind of limited to the same kind of assistance they give to Boeing. They can't run the city's street lights, but they can help the city do a quantity buy on LED street lights, or something like that" (interview, Seattle-based engineering and environmental consultant).

One example of this regulatory framework acting to prevent infrastructure integration can be seen in attempts to create a city-owned fibre broadband network. Since the early 2000s several mayors have pushed for either more competition within the telecommunications industry or for the creation of a publicly-owned utility that could provide services alongside the private operators. While there is a clear interest in using telecommunication technologies to create a smart electricity grid, the accountancy rules mean Seattle City Light is prohibited from funding any broadband network that can be managed as a separate telecommunications utility. One City Light interviewee said so far no study has been able to demonstrate that a publicly-owned fibre network could exist without heavy subsidisation from the city, adding:

> "If they wanted us to build it we could build it, we could do whatever they wanted, but they would have to fund it, they would have to pay for it, because both our bond consul and the city law department said we don't have the legal authority to run anything other than an electric utility" (Interview City Light executive).

While the accountancy laws seem to prohibit City Light funding a broadband network there is enthusiasm from telecommunications officers who see the opportunity to shift utility business models to providing services instead of products, as a form of MUSCo-type thinking:

> "It's a cultural shift moving from a utility model… their [City Light] main business is to provide safe, affordable reliable power, and operate under basically a monopoly model of guaranteed rate of return. It's a different shift to getting into more of a proprietary competitive [model]" (City of Seattle director).

However, another senior City Light executive dismissed the notion of an energy-run fibre network:

> "We have never considered our own telecommunications company seriously within the electric utility" (Interview, City Light executive).

Another interviewee added:

> "I don't think they have enough money. I mean it costs a lot of money to do that, and then I don't think that the existing providers are going to be fast asleep while these guys are building their network. I would not be surprised if they didn't lower their prices, and improve their services, because the last thing they want to do is see this spread across the country. So, I don't think it's going to happen. I think there is a group of people who are thinking about doing this, but I don't think it reflects, what I say is the feeling of the majority of the people of the city. Why should we be spending all this money on all of this, when we are still struggling with providing basic public services?" (interview, University of Washington academic).

The city's private providers are vocally opposed to any publicly-backed competition. However, the threat of the city providing its own broadband services is seen as a way to further spur private innovation. One respondent said:

> "The strategic approach is letting the private sector know that this is an option that the Mayor is willing to consider: if you don't, [we will]" (interview, City of Seattle director).

While Seattle is struggling in its attempt to negotiate around the accountancy rules to develop a city-owned broadband utility, the nearby city of Tacoma is not. Tacoma's Click network is a $200 million fibre-optic network originally designed in the 1990s with the smart grid in mind to provide "efficient power maintenance and an alternative to a local cable monopoly that provided limited offerings and lousy service" (Martin 2015). One Seattle interviewee said:

> "…the rumour is, so it's a fairly… more than a rumour, it's close to fact, is that Tacoma Click is being subsidised by the utilities. Which would be illegal under the State Accountancy Act…I don't think that they have actually found a loophole, I think they are just doing that undercover, illegally, but I have no evidence to support that, other than people that I talk to" (interview, retired City of Seattle executive).

### 5.3.2 The Role of Urban Politics

The second issue that affects infrastructure integration within Seattle is the disparate ideologies of those involved in the governance of urban infrastructures with tensions arising between employers, unions, and citizens. While the accountancy rules in Washington State work against forms of infrastructure integration from a regulatory, top-down perspective, the existing departmental fragmentation within Seattle is continuously reinforced and renewed from actors *within* the various city departments: politicians campaigning for re-election; unions aiming to retain the technical expertise of employees and protect their power base; elites hoping to consolidate their power; and a mayoral system that largely ignores the mundane, operational workings of infrastructures to focus on popular, voter-friendly policies. In Seattle, these internal political issues can both hinder and facilitate infrastructure integration. One problem in the management of large infrastructure networks globally is the tension between the need for long-term technical and operational management and the external threat of political actors seeking to exert democratic control over decisions. Large technical systems can be highly political and "epitomize the divergent, yet usually short term-oriented ambitions and interests of political decision makers" (van den Hurk and Verhoest 2015: 204). In Seattle, there are two aspects of political interference that warrant attention: First, is top-down interference from politicians, and second, the ideologies and activities of actors operating within the utilities. I will examine each of these issues in turn.

First, is the nature of top-down political interference in the long-term management of infrastructures. This can lead to problems, as one interviewee outlined:

> "Traditionally the electricity rates have been kept low by the politicians for political reasons, which means City Light hasn't really been able to invest in the infrastructure and the upgrades to

the infrastructure that it needs. So, there is a fear that if you go to integration or joined up operations of some sort, even more money will be siphoned off" (interview, retired City of Seattle executive).

Political intervention is viewed as inevitable within Seattle: having a city-owned energy and water supply inevitably leads to political pressure to keep prices low and service high from politicians making campaign promises to get re-elected. As one interviewee put it: "you just don't know with politicians, what they are going to do or what they are going to insist on" (interview, City Light executive). One example is the creation of SPU in the late 1990s. Mayor Norman Rice merged several utility departments in 1997 to create Seattle Public Utilities (SPU). This merger:

"…combined the water department and the solid waste, drainage, and wastewater utilities that had been part of the engineering department (together all the city's utilities except City Light, which remained independent) to create Seattle Public Utilities (SPU). That new beginning marked the end of independent existence for two historic entities: the Seattle Water Department and the Seattle Engineering Department, as the latter's Engineering Services Division also became part of SPU, while its traffic and transportation sections became part of the new Seattle Department of Transportation (SDOT)" (Henry 2007).

While this form of organisational integration can be understood from a technical standpoint – the separation of the water utility's engineering department and the city's own engineering department appeared to be a historic anomaly – one respondent felt the integration was forced through politically because:

"…at the time the Mayor felt he had too many direct reports. It wasn't this intentional thing of saying 'I see, you know, incredible opportunities', I think it was just much more of… too many departments, too many reports" (interview, SPU executive).

When asked if this example of departmental integration demonstrated unwieldy mayoral power, the respondent said:

"I wouldn't necessarily say that, in part because when mayors tend to speak they stick to high-level policy objectives and then they leave the day-to-day work of carrying out the service delivery to the departments. What that mayor basically did… he was doing something for organisational effectiveness in his own chain of command, which is saying I would like to streamline, but it was up to the departments to figure out what's the best way to integrate, and we're still learning on that. The functions are different enough that you can't just assume that things are going to mesh well" (interview, SPU executive).

This form of political interference was not necessarily seen as a negative aspect of the city's institutional framework. Several respondents highlighted the benefits of having a public-sector lead organisation that can outline overall visions for the city:

"The best thing I would recommend for the city of Seattle, or any city, is to create an overall vision, sort of like a straw person, share that with all the stakeholders, let them have a way in, and see if we can come up with a demonstration project and if that project can work, maybe then we can build on that and go forward (interview, University of Washington academic).

> "I think only the city or government can paint that vision, because if we are going to build or do major repairs on a significant street that goes from one part of town to another, what are the things we should be doing, when they are opening that street, to make sure we don't have to do it again? What can we do to make sure we don't have to open up the streets for maybe water sewage or gas, can we do the preliminary planning, where we put those things in place? (interview, University of Washington academic).

> "…maybe it is giving too much power to somebody, but somebody should be organising, coordinating… it's not like we have too many carrots to give" (interview City of Seattle director)

However, one respondent from City Light criticised the input from politicians:

> "It goes back to the fact that there is no engineer, there is no person who understands this and has a vision, but everybody fishing for votes with public opinion deeming certain shiny objects as desirable, and then the whole thing doesn't fit together. What a surprise [laughs]" (interview, City Light executive).

While this level of visionary thinking should occur at the policy-making level, it does allow for workers to concentrate on their day-to-day operational tasks without continuous political involvement. One interviewee said:

> "…the utilities are not very interesting from a political standpoint, and so they don't get very much attention. If you look at the city budget the utilities are two thirds of the budget, but they probably get less than 10 per cent of the political attention. It means there is not a huge amount of political will to say 'we are going to force you to do these things that we think are really good, even though you may not want to do them'. So, that kind of acts against integration because of course everybody wants their own turf and control and nobody is really there to knock heads" (Interview, former city councillor).

While the two major utilities are often ignored by the politicians they do come into focus when other city projects are struggling for funding:

> "In many cases both SPU and City Light are afterthoughts, except for 'gee is there any way we can figure out a way for them to help us fund something'" (Interview, City Light executive).

The interviewee added:

> "Every year, when it came to budget time, at least one council member would come to me with an idea about how he was going to take some of City Light's money. And every year I would have to explain that 'no, you cannot do this. This is not allowed under state law'" (interview, City Light executive).

The second aspect of political interference emerges from actors within the utilities themselves. Both utility managers and unions demonstrate signs of empire building with attempts to consolidate their power base in antipathy to each other. While the state accountancy rules work to enforce a degree of separation between the energy and water utilities, this separation is also a desired outcome for many of the actors involved in infrastructural management. Integration is often viewed as a negative feature for a number of respondents within City Light and several interviewees discussed the

workings of high-level executives who act to prevent forms of integration with other infrastructures and with other city departments. A project to centralise the city's IT systems was mentioned as problematic by numerous respondents who saw various factions fighting for control. One interviewee said:

> "…what they are trying to do is just have a single data centre where all the City of Seattle functions are housed, and [named utility executive] has been very, very resistant to that" (Interview, retired City of Seattle director).

Another energy executive outlined his own opposition to the centralisation of IT services:

> "…there is a large effort to further centralise IT services, with the underlying textbook assumption that there are economies of scale, and centralisation is better. What that doesn't take into account is that you may be serving very different needs. We are an engineering company and so is our sister utility, the water utility, SPU. As such, as an engineering company, we are a lot closer to the investor-owned-utility across the lake, Puget Sound Energy, than to the Department of Parks. If you issue a dog tag a day late, bad, but the world doesn't collapse. If something breaks in our engineering systems and in our real-time systems, the lights go out and you are going to have riots in the streets and Boeing is losing millions of dollars" (interview, City Light executive).

This focus on budget protectionism – reinforced by the state accountancy laws – leads to the 'siloing' of Seattle's infrastructures, which appears to be the more desirable ideal for high-level officials within City Light than any concept of infrastructure integration. While dismissing the importance of the accountancy rules in preventing the creation of a city-owned broadband company one respondent highlighted the thinking:

> "It's just a matter of working out the details. But, [named city executive] specifically opposes that. He has opposed it tooth and nail because he fears that such a broadband utility would be supported by electricity rates and therefore siphon money away from the electric utility (Interview, retired City of Seattle director).

The city's unions have also acted to prevent infrastructure integration and cross-departmental convergence in an effort to protect the valuable and well remunerated technical skills of their workers. One respondent said:

> "The biggest issue is probably job security, if we do integration… what will happen to my job and job security, especially among public employees who are expecting a pension. You work 30 years and you get a pension. So, I think that's a big issue. And then I think there is this personal empire building, to some extent that's an issue as well" (Interview, retired City of Seattle director).

Another interviewee from SPU added:

> "I think there are some barriers in this city to [integration]. One of them is this city has a very structured union. It's a very… I guess people would call it a progressive city [laughs]. And so the work is broken up into specific unions. Unions have specific pieces of the work, and so trying to integrate that, there are challenges with it, trying to get the operational and more integrated in doing that" (interview, City of Seattle director)

Another interviewee provided an example of the unions working against infrastructure integration:

> "I wanted to consolidate networks and data centres and server and desktop management, and it failed. The primary reason it failed was that the employees in my department who did that work were not unionised. Most of the employees in the other departments were unionised, and frankly the union, even though we kind of worked it out so that they wouldn't lose their trade union affiliation during the consolidation, the union basically said to the city council 'you know kill this, because we are going to lose union representation'. That was the reason the integration, the centralisation, failed" (Interview, retired City of Seattle director).

A previous attempt to integrate the city's radio networks also failed, largely due to animosity and distrust between the employers and the unions:

> "The city government has three radio networks. One for police, fire and public utilities, that are run out of the central IT shop, transportation has a separate one, and Seattle City Light of course has its own radio network for dispatching its own vehicles. I wanted to consolidate those as well, but again [named city executive] wouldn't even consider it. He wouldn't even look at it because the radio technicians were represented by electrical workers… which is kind of odd, but they were… and so he didn't want union jobs. He refused to consider consolidation. I mean why do we have three sets of radio towers? It's just stupid" (Interview, retired City of Seattle director).

In April 2016 the city did create a single, centralised IT department to serve all the city departments, however the plans were only approved after guarantees to the unions that there would be no job losses (Wood 2015).

### 5.3.3 Direct Democracy

The third issue that influences infrastructure integration in Seattle relates to *democratic* initiatives. Washington State is one of several western US states to operate a form of direct democracy that allows for initiatives and referenda to be proposed by voters and for any issue to be placed on a ballot if it can generate enough initial support. This process has led to an active citizenry fighting for more renewable energy projects, often against the advice of engineers and technicians, creating a bottom-up challenge to infrastructural management. Washington became one of the first states to enact this form of direct democracy in 1912 (Office of the Secretary of State Elections Division 2013) largely due to what one respondent described as corruption practices from early railroad monopolies (interview, University of Washington academic). If voters can get a petition signed by eight per cent of voters then the initiative must be put to popular ballot (Office of the Secretary of State Elections Division 2013). One respondent outlined the pros and cons to this system:

> "Much of what we can do in government is initiative driven, and many people are concerned that the initiative process is being abused. Because it sounds like a good idea, so let's go do it, but there's no real debate. We're voting for a piece of legislation right now… there is an [education] initiative to reduce all K group 12 to something like 20 students. Now if that passes where are we going to find the money for that?" (Interview, University of Washington academic).

The interviewee also discussed the problems in using direct democracy to govern large infrastructures:

> "I think the experts can get neglected in these types of issues, I think it's a very good idea and over time I think all good ideas have to be revisited because they can kind of go bad on you. And many of our initiatives were formulated by a person who was very, very, anti-government, and he has put together a large number of initiatives to roll back taxes… now you can't raise taxes in this state unless you get a two-thirds vote of the state legislature, not just a normal majority… so that gives the minority party a complete lock on whether or not we will be able to raise revenue" (Interview, University of Washington academic).

Another respondent raised a similar point in relation to California:

> "It seems to me to be a poor way to do government, because you're passing a lot of things that no one wants to pay for, so for instance California passed a referendum where you could not raise taxes without two thirds of the vote of the legislation. Well you can't get two thirds of the vote of the legislature on anything. So the tax revenue was basically at a standstill, and then you've got roads falling apart and pension costs rising, and things like that. You just have these incredibly poor outcomes. (Interview, transportation official).

In 2006 one such voter-led initiative in Washington saw the passing of a Clean Energy Initiative (Initiative 937) which called for the creation of Renewable Portfolio Standards (RPS). The RPS requires energy utilities serving more than 25,000 customers to produce a share of their electricity from renewables, mandating that providers must produce or purchase Renewable Energy Credits (RECs) to cover three per cent of their electricity load by 2012, nine per cent by 2016 and 15 per cent by 2020 (Washington Policy Center 2013). The initiative passed with 52 per cent of the vote. The initiative stipulates that the existing hydroelectric plans within Washington State do not count as renewables. One respondent described this as a way to stimulate the wind and solar industry ("they didn't want to give you credit for stuff that was built 40 years ago," interview, City of Seattle director). Another criticised the entire process for taking technical decisions out of the hands of engineering experts with knowledge of infrastructures (interview, City Light executive). Although the Save Our Wild Salmon Coalition has said that wind development and restoring salmon stocks can go hand in hand (Ford 2011), in 2008 an unexpected surge in wind production created too much energy for the regional grid with the dams spilling water to cut their power. This spillage saturated the rivers with nitrogen-rich air, killing large stocks of salmon (Tilkin 2008). One interviewee said:

> "From a Seattle City Light perspective, wind power kills salmon. For some divine reason Washington does not recognise hydroelectricity as renewable, even though it rains all day long. So, hats off to the solar and wind lobby. Yet we are obliged to take 15 per cent from those sources. We have enough hydro power. We can run this whole city on hydro. But what we have to do in order to 'comply with the law'… here again, it shows you how laws accomplish the opposite of what they are meant to do, while the hand of the market would have probably worked a lot better. So now we have to take 15 per cent in wind energy, which means we are throttling back the generators at the dams. The dams work best, or a hydro generator works best, either at very low load, or at very high load. In between it runs sub-optimal, and as a by-product oxygenates the rivers, which induces gasification in fish. It's like a diver when you come up too

fast, so now we have fish dying, because we have got to take wind power, because it's better for the environment, right?" (interview, City Light executive).

The creation of Renewable Portfolio Standards has also created potential geographic conflicts with cross-state commerce laws – the constitutional principle that the free flow of commerce between states should not be impeded. This includes interstate transfers of electricity (Jubien 1996). A number of states have stipulated that their RPS must contain a certain proportion of energy to be produced locally (politically to try to stimulate a local renewable industry). In California, the largest electricity market in the western US, the RPS rules stipulate that 75 per cent of renewable energy must be "Category 1"-type energy, or from facilities directly interconnected to the California grid (Donnelly-Shores 2013). Energy producers in nearby states complain that the rules prevent new high-voltage projects from competing on a level playing field with Californian energy options (Hodges-Copple 2012) and one respondent said the strict RPS rules may breach interstate free commerce laws:

> "It's questionable as to whether or not that is constitutional. Nobody has challenged it. But there actually have been things on other sites… other kinds of stuff besides electric power, where the Supreme Court has ruled that attempts to prevent people from outside your city or outside your state, movement of commerce, is not constitutional. It's kind of a tricky legal area, and you never know when the court is going to go which way" (Interview, city engineering and environmental consultant).

Another interviewee said Washington wind farms in the Cascadian mountain range were beginning to suffer:

> "It has driven the wind developers who have options up here mad, because a whole bunch of the wind that was developed in the Columbia Gorge is exported to California, and now no more can be, because of that restriction. Well the US constitution has a commerce clause that says that states can't restrict commerce among the states. That is unconstitutional. But nobody has been willing… they have from time to time rattled that sabre, but as far as I know they haven't actually filed suit. I think it's primarily because the wind developers who would be pursuing the litigation, they don't want to piss off the utilities all that much because they are trying to sell to the utilities. So… they are a little reluctant to sue, but when we were getting our RPS looked at, the lawyers who looked at it said you could easily have a commerce clause problem with this, and we said 'yeah, and if they sue, they sue', you know" (Interview, environmental consultant).

## 5.4 Discussion: Introducing Evolutionary Integration

Infrastructure integration within Seattle is very much a product of the institutional environment of the city. What emerged during this research is the concept of infrastructure integration occurring in what I term is an *evolutionary* process that is opportunity-driven, arising out of the day-to-day operational interactions between engineers, policy makers, socio-technical networks and citizens, rather than integration being a normative ideal that the city should strive towards as an end goal.

Using the conceptual framework developed in Chapter 2, this form of evolutionary integration can be graphically represented in Figure 5.2.

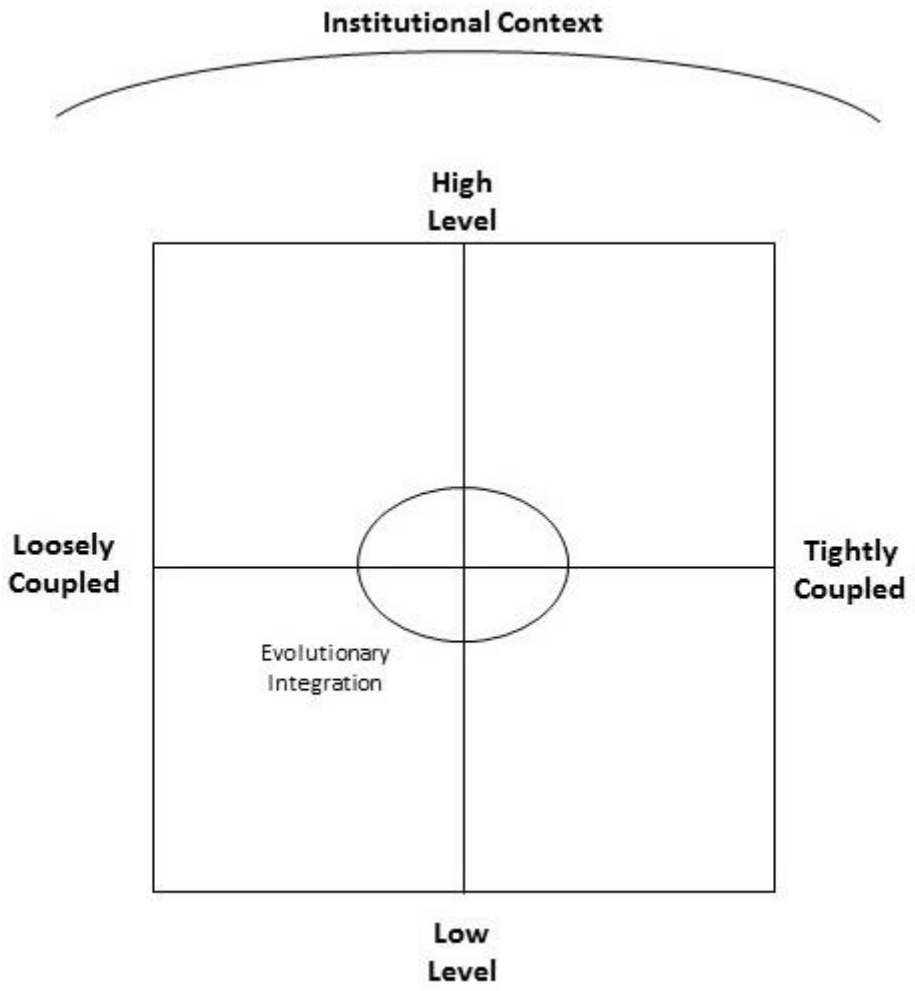


**FIGURE 5-2 SEATTLE'S EVOLUTIONARY FORM OF INFRASTRUCTURE INTEGRATION.**

Key here is the recognition that infrastructure integration occurs only when the opportunity arises, and only if it results in demonstrable improvements to current governance arrangements or service provision. It appears that infrastructure integration occurs only if the benefits outweigh the negatives and moves towards infrastructure integration are taking place on a piecemeal basis without overt coercion or even explicit knowledge that there should be a more integrated future. The integration of infrastructures is not seen as something inevitable and there are no grand policy objectives or strong desires to create integrated visions for the future city. Utilities within Seattle remain siloed for a number of reasons: through political interventions, various forms of judicial and regulatory splintering, and democratic pressures from citizens. However, integration still occurs as the inevitable consequence of the daily interactions involved in infrastructural delivery, for example in city planning through departments sharing GIS datasets or through departmental partnership

working in laying cables under the city streets. The natural advantages provided by the physical geography of the city (allowing for some of the lowest energy rates in the country), as well as the adaptive capacities made available by the city owning of key utilities, offers Seattle multiple options for the future direction of the urban fabric. Integration is just one option, however the concept is largely absent from the urban discourse. The judicial splintering within Seattle prevents forms of 'tightly coupled' integration from occurring in organisational terms, while the lack of any 'high level' strategy directing integration as a clear policy goal leads to integration being pursued within the city departments only if it is necessary. It is instead enacted at an operational level by those involved in the day-to-day management of infrastructures. Thus, we can situate evolutionary integration to be within the centre of the conceptual framework shown in Figure 5.2. There are three points to make in relation to what I argue is evolutionary integration.

First, the concept of integration as a policy to be pursued in relation to infrastructural networks has not yet found its way into the American discourse (interview, University of Washington academic). As such, infrastructure integration is not necessarily viewed as a normative ideal that can improve performance or to meet environmental goals, partly because it is widely believed that Seattle already performs well on infrastructural delivery. Seattle already has conducive networks for infrastructural management (at least, in the view of interviewees). The city has both the energy and water utilities under public management; most city departments are located in the same building (Seattle Municipal Tower on 5th Avenue); and the surrounding physical environment can provide abundant water and hydroelectric power to residents and businesses. As a result, integration is seen as something that *may* be desirable to improve infrastructures, but it is not the only option. Radical changes to infrastructural management are unnecessary and largely unwanted. The 'siloing' that occurs between infrastructures is enforced through the regulatory structure at the state level: something the City of Seattle has little ability to change. This segregation is also seen by key actors as beneficial, both ideologically in terms of officials opposing certain cross-subsidisation policies that may dilute their authority, and through the daily operational practices that continuously reinforce the splintered environment – officials within the energy utility focus mainly on energy projects, officials within the water utility focus mainly on water projects etc. This research reinforces the argument put forward by Gluck and Meister that the structure of the civil service within the United States can lead to an "agency-based decentralization of political power, duplication of services, red tape and a concern for self-preservation" (Gluck and Meister 1979: 116). The energy and water utilities were founded to only fund projects that relate to their core mission and little has changed in terms of their core nexus. Any forms of organisational integration between them is viewed as unnecessary and unwanted with the potential to dilute Seattle's very strong sustainable goals in favour of political pet projects that could be introduced at any time. As one interviewee said, "let the engineers manage" (interview, City Light executive).

Second, any infrastructure integration that does occur within the city is opportunity driven and evolutionary in terms of emerging from the day-to-day governance of the infrastructures. The one example of politically-driven integration (the creation of SPU in 1997) still relied on the technicians and officials to come together and themselves draft the details on how the consolidation would work. While Mayor Norman Rice had an explicit goal to merge the city's core engineering functions, exactly *how* that merger occurred was left to city officials within the affected departments. Today there is little political will to force other forms of infrastructure integration through the various city departments or to force the utilities to work more in partnership with each other. This reinforces the

argument that pressure for infrastructural change can often come from outside of the city departments, with "policy making in general [being] a relatively slow moving process, with decisive action difficult to accomplish" (Clingermayer and Feiock 2001: 11). There are perhaps more features within Seattle that work against infrastructure integration than facilitate it. The strong regulatory structure at the state level, the ignorance of day-to-day operational tasks within the political hierarchy, and the reluctance to dilute personal and union power from within the segregated departments all work against forms of integration.

Third, while some forms of organisational integration may be difficult (and unwanted) Seattle does offer an example of how the strategic and visionary organisational lead as envisioned under the system of systems approach may work in practice. The Specifier-Provider model developed within SPU offers an example of how viewing the city as a system of systems may work. The city aims to understand what forms of infrastructure provision is needed, it decides what work needs to be prioritised, and then contracts the work to external 'providers' as needed. There is little need for a multi-utility ownership model such as a MUSCo under such a structure. As Mercier et al (2016) argue the city authority is a proactive player in directing private sectors players to meet preferred policy objectives. The Specifier-Provider model is also an example of city officials seeking to learn from best practice, exploring how technicians in Australia manage their own networks, and seeking to adapt the model to the Seattle environment.

To conclude, in outlining what I argue is the evolutionary form of infrastructure integration, one respondent said:

> "Regardless of whatever structure you're in, good people will be able to make it work and deliver services, and what you need to understand is what's the structure that you're in now, and what are the inherent weaknesses of it, and how can you try and cover for those, bridge those, you need to think actively how. So now we are moving into a more siloed structure, we have to think pretty hard about what kinds of things will we do to still allow for the cross-pollination and the coordination between the lines of business to happen, because structurally it will be a little bit more difficult, so you will need to put a little bit more energy into making sure that happens" (interview, SPU executive).

# 6 MUNICH – THE INNOVATIVE CITY

Munich was chosen as a case study for this research due to its reputation as a city with strong institutional frameworks for urban governance (Evans and Karecha 2014) and as a city that is actively pursuing and supporting various forms of infrastructure integration (Bayern Design 2014, Mailer et al. 2014, Reiss-Schmidt 2004). As in many German cities Munich's infrastructure is governed through the *Stadtwerke* – a city-owned enterprise that provides electricity, gas, water, transport and telecommunications. The *Stadtwerke* would appear to provide an appropriate location for forms of infrastructure integration to occur and there appears to be strong networks between public and private actors involved in urban governance that could facilitate forms of integration. What has emerged during the research process is that Munich offers an example of what I term *innovative* infrastructure integration, or infrastructure integration occurring as a result of *innovative urban processes* that are inherent to the institutional structure that exists within the city: a strong mix of technological innovative companies; individualised and context-specific governance arrangements; tailored technological solutions for individual projects; and flexible organisations able to adapt quickly to complex changes in national and international regulatory regimes.

This chapter begins with an outline of the institutional context of Munich and an exploration of how the city's urban infrastructures are governed. Then I discuss what interviewees thought about the concept of infrastructure integration, grouping their responses into three main themes: the need for holistic urban planning, the importance of strategic masterplan documents, and the importance of the 'Munich mix 'of innovative public and private organisations. Next, I examine two issues that impact upon infrastructure integration within Munich: first, through actor-led initiatives that are facilitated within Munich's decentralised and consensus-seeking power structures and second, through regulatory shifts at the European level which are changing the governance structures within which Munich's infrastructures are managed. I end this chapter with a discussion of what I describe is the innovative form of infrastructure integration

## 6.1 MUNICH'S INSTITUTIONAL FRAMEWORK

Munich is the state capital of Bavaria in south east Germany (Figure 6.1). It is the third largest city in Germany (behind Berlin and Hamburg) with a population of 1.4 million people and it is expected to grow to 1.7 million by 2030 (City of Munich 2013). While historically the city's economy has been based around manufacturing the city today is a leading international city region with growing areas in biotechnology, information and communications technology (ICTs), insurance and banking (While, Gibbs and Jonas 2013). In the core city centre are the headquarters or major offices of major global corporations such as BMW, Siemens, Allianz, Microsoft, and DASA. The city contains two of Germany's leading universities (Ludwig Maximilian University and the Technical University of Munich), it has the lowest unemployment rate in Germany and is the second largest employment centre after Berlin (Evans and Karecha 2014). By most metrics, Munich appears to be economically successful and politically stable: it is an important international location for businesses, a vital node

in the global space of flows (Goebel and Thierstein 2006) and one of the most competitive metropolitan areas in Germany (Lüthi, Thierstein and Goebel 2007).

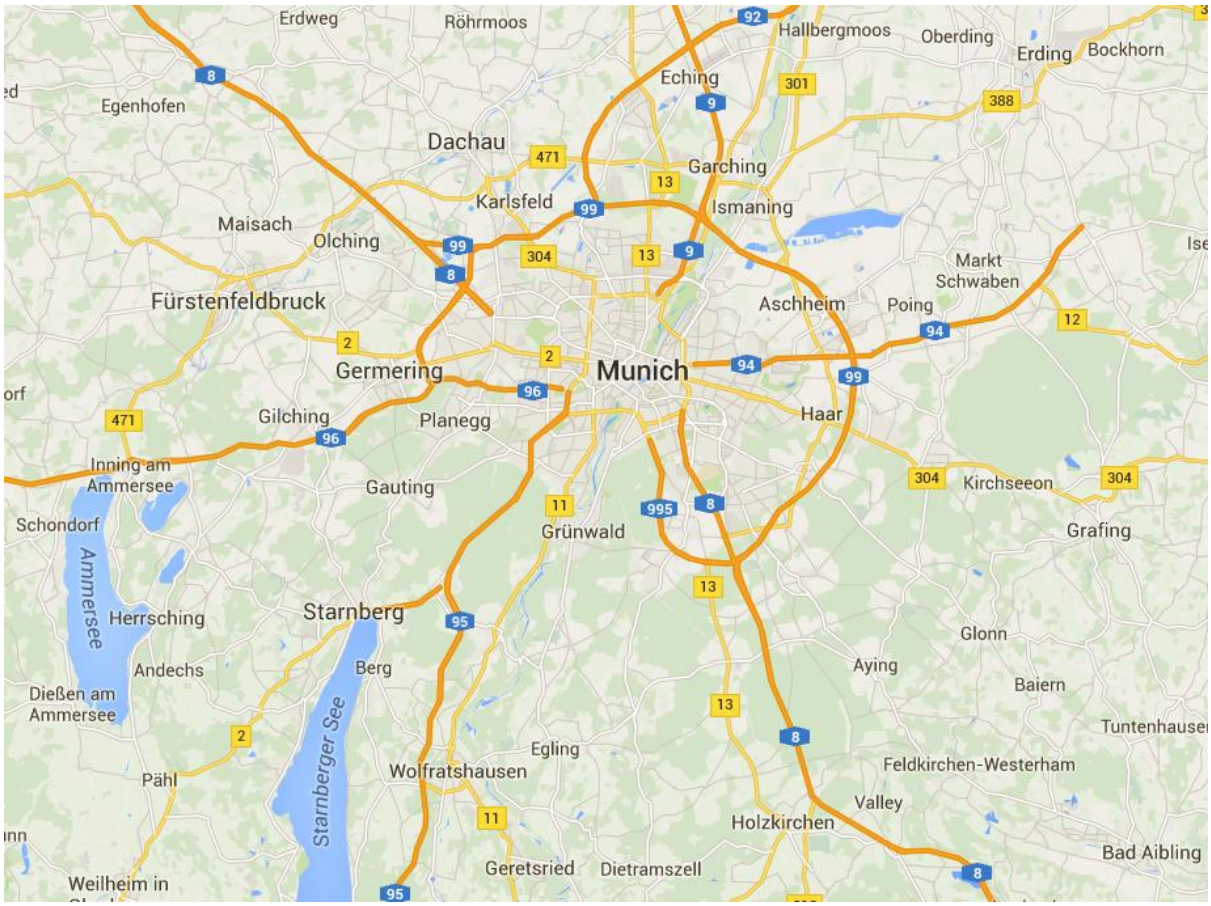


**FIGURE 6-1 THE CITY OF MUNICH**

Munich was ranked as the number one liveable city in the world by Monocle magazine in both 2010 and 2012 due to its extended quality of life and its high technological innovation, large amount of knowledge-intensive industries, rapid job growth and low unemployment rate. Its investment in infrastructure since the Second World War and large private sector growth has led to Munich becoming known for its sectoral diversity and specialist clusters, or what some researchers call the "Munich Mix" involving the combination of economic competitiveness, environmental sustainability and social cohesion (Evans and Karecha 2014).

Research for this project is focused upon the wider Munich Metropolitan region, which has a population of 5.5 million. There is a degree of regional cooperation that occurs with the City of Munich and the surrounding authorities, and strong regional governance networks that govern the area's infrastructures at a regional level, rather than at the city scale. However, despite much of the academic literature highlighting and discussing issues within and beyond the "Munich City Region", in structural terms the 'region' does not actually exist (Reiss-Schmidt 2004). There is no elected regional council, regional president or strong regional administration acting on behalf of the Munich city region. Instead, regionalism in and around the city of Munich is based on a consensual and voluntary cooperative approach to "governance instead of government" (Reiss-Schmidt 2004: 4)

with actors engaging voluntarily outside of any formal structure. The state of Bavaria works with the eight rural county councils and the 185 local administrations in discussing plans that can affect the city region.

Politically, while the state of Bavaria is highly conservative – since 1946 all state prime ministers have belonged to the conservative CSU, except for one during 1954 and 1957 (Kauder and Potrafke 2015) – the city of Munich is a "left of centre island within Germany's most conservative state" (Monaghan 2014). From 1993 until 2014 Christian Ude, from the Munich Social Democratic Party (SDP), was mayor at the head of a coalition between the SDP and the Green Party. The political stability of the city and the wider region has been cited as a major reason for the city's economic success (Evans and Karecha 2014).

The concept of public interventionism is prevalent within the German formulation of the state which leads to the possibility (and often reality) of significant political interventions in public service provision (Lorrain 2005). In Munich, this often translates into conflicts between bottom-up representation from a strong local municipal democracy and top-down pressures from state politicians and business leaders who wish to see the wider city region represented as a single whole. There are tensions between inclusive citizen participation processes and the pragmatic desire to only act once there is a consensus, however the decentralised and multi-level governance structure has allowed the city region to develop its competitive edge (Evans and Karecha 2014). It has been argued that governance in Munich is focused on consensus-seeking and conflict aversion rather than decisions taken by decree (Hajer and Kesselring 1999). While this can provide scope for visionary and entrepreneurial leadership (by allowing small teams to experiment with new technologies and governance techniques) it can also mean decision-making is slow, arduous, and non-contentious (Hajer and Kesselring 1999). This is exemplified through the large variety of actors involved in regional planning within and around Munich. Major decisions on land use and infrastructural investment, for example, are taken within the Regional Planning Association (the *Regionaler Planungsverband München*) a group comprised of the communities in a 50km circle surrounding the city centre. The creation of the RPM in 1973 led to high-level policy discussions between the state and municipalities and now results in a regional plan to provide a legal framework for local land use policies. This form of decision-making operates through "cooperation and negotiation instead of ruling by power" (Reiss-Schmidt 2004) with the desire to seek consensus between disparate actors and state leaders lacking in authority to oppose or veto certain policies. Civic authorities at the local scale have their own decision-making abilities in relation to the administrative weakness of the regional centre. The reality of trying to get hundreds of geographically-bound elected officials to cooperate was discussed by one interviewee:

> "Regional cooperation, not only in transport but also in urban sprawl and social and schools and so on is really a problem in Germany, especially in Bavaria, because in Bavaria the regional planning authorities are not very strong, they don't have much influence, they coordinate a little bit but in Germany every community can decide about houses and streets and so on, and we have a lot of communities here around Munich, and now we've just had a conference last week with 400 mayors of the region of Munich (interview, City of Munich transport official).

Another interviewee added:

> "It's very difficult. That's the other thing about Munich: the public always has to get involved, so participation is a very important thing. There are 400 people [in these meetings] and everybody has a different opinion and it's really difficult for the planner to say 'ok we have to do it this way' because any time anyone doesn't agree and has problems with the decisions..." (interview, City of Munich planner).

Decisions are taken by local mayors who adopt a regional plan to coordinate the planning process, while local authorities can develop their own plans in relation to the regional plan as long as there are no adverse effects on neighbouring communities (Goebel and Thierstein 2006). While many see Munich's wider fiscal and political autonomy as key to the city's economic success, others argue that the strong autonomy of small municipalities within the wider region has constrained contentious policy decisions, such as the "Bavarian State recommendation that growth should be concentrated in the large municipalities" (Droß and Thierstein, 2007, quoted in While et al, 2013: 2386). The Chamber of Commerce is also critical of the regional plan structure, arguing that "fast adequate decisions of firms are blocked because of this inflexible instrument" (Goebel and Thierstein 2006: 5). While the Munich decision-making structure may be adequate for making certain decisions the impacts of municipal state autonomy at the local level has been described as "liberating, progressive, paralysing and regressive" (While et al. 2013: 2393). One interviewee explained how the local municipalities operate:

> "They have their own governance… the administration field, they have their own politicians, they can make decisions, they can go to the city council, and say 'yeah we want this in our city district' and they always have to be involved if there are any decisions, so that's quite a strong structure in Munich. Sometimes it's hard to get them together, or if you have an aim for a district, you always have to involve them. If they don't agree it's very difficult to get a decision, so it makes it quite difficult, but on the other side it's a very democratic way, because the people who live in the districts can say 'we want this and that', and that's their way to communicate with the city council. So, it's not so easy for the administration, but for democracy it's quite a good thing" (interview, City of Munich planner).

The fragmented sub-regional governance has led to problems in coordinating certain infrastructural decisions (such as disputes over an expansion to Munich Airport) and has "frustrated attempts to achieve integrated land and transportation planning and led to car dependency and increased congestion" (Evans and Karecha 2014: 1265).

The governance arrangements of Munich's infrastructures are outlined in Table 6.1. The key infrastructures in Munich are owned and operated by the city-owned S*tadtwerke* (the *Stadtwerke München GmbH* (SWM) or Munich City Utilities). The SWM is a communal company and provides electricity, natural gas, district heating, and drinking water. The SWM is Europe's largest municipal utility company with an annual budget of €9 billion (Stadtwerke München GmbH 2015). The public ethos of the SWM and its desire to engage with the mixed economy of Munich is evident in its desire to remain "a guarantor of the quality of life and economic strength of the metropolitan region of Munich, committed to long-term citizen value" (Stadtwerke München GmbH 2015: 8). A subsidiary of SWM, the *Münchner Verkehrsgesellschaft MbH* (MVG), operates most of the inner city public transportation network and maintains the Munich U-Bahn, the Munich Tramway and bus services. The SWM, along with several other Bavarian *Stadtwerke*, is also a major shareholder in M-Net, a

telecommunications utility created to deploy fibre broadband across the state of Bavaria. Waste management in the city is handled through the AWM, another subsidiary of SWM. The City of Munich also has financial interests in several highly profitable private companies such as Munich Airport, the Munich Fair Trade Company, and the Munich Olympia Park (Evans and Karecha 2014).

Within the city region individual citizens are able to propose and enact referenda to enact policies if they can get the required number of signatures. While referenda are forbidden at the German federal level they are often used as a machination of governance at the state and municipal level (Loughlin and Aja 2006). However, the practical power offered to citizens in relation to infrastructural decisions has been called into question with controversy over plans to build a third runway at the Bavarian-owned Munich Airport. Although a 2012 referendum held in Munich showed clear opposition to the expansion, a federal court struck down the opposition in 2015 and allowed the expansion to proceed (Bryan 2015).

While there is evidence of a culture of local direct democracy within the city region, and despite the *concept* of consensual decision-making between neighbouring districts, in practice many of the smaller surrounding communities fear they are at risk of being overruled by the City of Munich:

> "It's sometimes hard to cooperate, because it's always the big City of Munich and these smaller towns are always a little bit afraid that Munich wants to change them. So, it's not so easy, it's very, very, difficult, and it's very important to have good networks, so you can know who to talk to" (interview, City of Munich planner).

A further pressure on Munich's infrastructure comes from the ability for city and state councillors to propose their own laws and regulations. In November 2014, the Conservative-led Bavarian government passed a '10H' law in relation to wind turbines, requiring new turbines to be at least 10 times their maximum height from residential buildings: a 200m high turbine would need to be at least 2km from the nearest residential building. This "distance is so great that it will become practically impossible to install more wind turbines" (National Wind Watch 2014) and the rule has essentially halted the deployment of new wind generation in Bavaria. One interviewee discussed the issue:

> "For us the wind market in Bavaria is dead already. We have the pipeline for the next three years, and then gone. Now they have the problem, what else do you want to do? We don't want a coal power plant, nuclear is shut off, solar we are good, but this is definitely not sufficient, so what do we do? Now they want a gas power plant, but they are not competitive anymore, because energy is cheap due to renewables, tremendously cheap, and we have the most up to date gas power already" (interview, Munich green engineering consultant).

| | Water | Sewage | Drainage | Heating | Energy | Waste | Transport | Telecommunications |
|---|---|---|---|---|---|---|---|---|
| **Main Actors** | Munich *Stadtwerke* (SWM), or 'City Works', operates several district heating grids, a power plant fleet for heat and electricity generation in the Munich area. | | | | | Waste management company AWM, owned by City of Munich | MVG, subsidiary of SWM | M-Net. Owned by SWM and other Bavarian *Statdwerke* |
| **Comments** | SWM is Europe's largest municipal utility company.<br>SWM Energy, an offshoot of SMW, acts as a standalone company to meet EU competition laws. Open market competition between energy actors, however strong local culture and distrust of the large national competitors mean 95 per cent of residents stay with the city-owned supplier. | | | | | Owns combined heat and power incineration plant in north Munich | MVG operates inner city transportation networks and the Munich U-Bahn, the Munich Tramway and bus services | Created from partnerships between several regional *Stadtwerke* to deploy fibre broadband across Bavaria. |
| **Other Actors** | National Big Four energy firms (EnBW, RWE, E.ON, Vattenfall)<br>Regional farming cooperatives operate large solar farms | | | | | | National rail routes managed by state-owned Deutsche Bahn | Deutsche Telekom (owns most of Munich's legacy infrastructure)<br>1&1 Internet<br>Alice<br>Unitymedia |
| **Principles** | • Concept of pragmatic municipalism (Lorrain 2005).<br>• City as a 'holistic' infrastructure provider.<br>• Strong culture towards city independence with Munich identity.<br>• European competition laws prevent cross-subsidisation. SWM Energy has thrived in relation to national competitors.<br>• Consensus-based infrastructural, regional and scalar governance networks.<br>• Focus on green growth. City aims for 100% renewable energy for customers by 2025, and a pure renewable district heating network by 2040. | | | | | | | |

**TABLE 6-1 THE MANAGEMENT OF MUNICH'S INFRASTRUCTURES**

## 6.2 Interviewee Perceptions of Infrastructure Integration

While Seattle offers an example of infrastructure integration proceeding somewhat organically through evolutionary processes, Munich differs in that the concept of integration appears to be prominent throughout the urban discourse. What is apparent is that interviewees see the concept of infrastructure integration as a positive and perhaps inevitable direction for infrastructure governance – it is something to be aimed for in and of itself. It could be argued that integration is woven into Munich's institutional culture and many respondents spoke of the need for the city to act as a holistic guarantor of urban services, offering a single city organisation to provide or contract for all the infrastructural needs of the city. One respondent described integration as encompassing "everything within urban development", adding:

> "In Germany, integration is not only about infrastructure [but] every aspect of urban development. [You analyse projects] with social demographics, housing, education, migration, green, infrastructure for children, and you compare the districts… and analyse how the different topics go together. That's what integration I think means in Munich" (interview, City of Munich planner).

In Munich, the discussion of infrastructure integration offered by interviewees can be grouped into three main themes. First, is the view that Munich should holistically plan and offer its own city-owned forms of infrastructural provision. The ability for a single organisation to be able to plan and provide for the various needs of urban citizens and businesses was cited as a key aim for the city, however this holistic provision should still operate within a competitive market environment alongside private infrastructural providers. Second, is the view that infrastructure integration should be an overt aim for city officials, and it can be achieved through the utilization of detailed urban masterplans: the integration of land use and infrastructural planning, and the ability for centrally-designed planning documents to act as pivot points around which decisions can be made and services provided, were both cited as important facets of urban policy. Third, is the importance placed on the public private innovation milieu that exists within Munich, and the cooperative practices that have evolved between businesses and city officials. I will examine each of these themes in turn.

### 6.2.1 Holistic Infrastructural Provision

The first theme that arose from the interviews is the view that the provision of infrastructures in an integrated way should be the *raison d'etre* of Munich's urban governance. Interviewees generally felt that power should lie with a strong local government and an associated powerful planning department able to direct investment to where it is needed and, if necessary, to provide services of its own. While competition within infrastructural sectors is possible (and necessary due to European laws) this acts as an incentive for the city to deliver high quality, low cost services of its own. Thinking of a city in holistic terms as an evolving urban whole reflects the institutional abilities of the city council and the prominent position of the *Stadtwerke* in being able to offer a multitude of

services to residents. Described as pragmatic municipalism (Lorrain 2005) this allows the city to guarantee a minimum level of infrastructural provision needed for the economy to function normally. While the UK variety of capitalism appears ideologically predisposed towards the private provision of services over public (Lorrain 2005, Loughlin and Aja 2006), in Germany the issue is less relevant. While there is a debate over the privatisation and financialisaton of local public assets, the public sector is viewed as just one viable and important market actor alongside the private sector (Loughlin and Aja 2006). Infrastructure integration within the city does not necessarily mean that Munich has to provide all services in-house, but instead is focused upon identifying what services are needed, assessing their current provision, and then using city-owned departments to either improve the existing services or create new ones in direct competition to other providers. This is similar to the system of systems approach to infrastructure discussed in Chapter 2 and this form of urban planning has evolved since the liberalisation of infrastructural markets across Europe in the late 1990s. Today the reality is a blurring of public and private provision. This extends not just to energy provision – where a public-sector generator can use the existing infrastructure alongside and in competition with private providers – but also involves the motivation and ability to create new and extensive physical networks to operate in parallel to the existing but often insufficient infrastructures. The ideological discourse within Munich's urban government does not necessarily revolve around public versus private provision (Bullman and Loughlin 2001). Rather, it focuses on the pragmatic issues of how to provide holistic high-quality services for citizens. One example is through the Bavarian-wide creation of the telecommunications company M-Net (60 per cent owned by the SWM) which competes directly with private-sector suppliers:

> "…step by step over the last 10 years, with every construction they put a fibre cable under the ground, and now they have a coverage of I think 95 per cent already, with their own cable, so they set up a parallel infrastructure, they are very strong now, I think they have a market share of almost 20 per cent, which is good after 10 years in this very competitive market of telecommunications, and they have big advantages, because they have the customer interface, the customer trusts M-Net, they have this 'we are Munich' feeling" (interview, Munich green engineering consultant).

This has advantages for a city-owned utility with the potential for cross-sector service offerings:

> "The [city-owned services] all share the customer interface. So, the face to the customer is one face. While you are visiting this, they can offer together with the electricity contract, a gas or heat contract as well. You have the choice" (interview, Munich green engineering consultant).

The concept of a strong Munich-based infrastructural provider and its ability to coordinate and develop several infrastructural networks simultaneously is also evident within the public transportation sector. Not only is MVG able to manage bus and tram lines but it is also able to offer cycling services and has an aim to integrate all levels of city transport:

> "That's really an advantage of our system… the responsibilities are clear. We make MVG a daughter of the City of Munich, it builds and runs and manages nearly the whole public transport system. Now they will also have a bike rental system to these lines. Only the S Bahn system is managed by the railway company… and the planning is in one hand here, and it's really integrated planning between urban development and transportation infrastructure, and that's very important" (interview, City of Munich transport official).

The 'We are Munich' culture provides an important discourse around which infrastructural decisions are made. Citizens can choose to stay with SWM as they can see visible signs of money being reinvested into the city region (interview, Munich green engineering consultant). While the ability to choose providers in energy, gas and telecommunications does exist the discourse of Munich allows residents to identify with the local *Stadtwerke*, and a desire for city independence has allowed the SMW to retain a large proportion of customers despite many services being offered more cheaply by other providers. One interviewee said:

> "They are happy with the… they are very patriotic, somehow. The S*tadtwerke* is something I know, there is a customer centre where I can go, everywhere I see the *Stadtwerke* people. I mean the *Stadtwerke* has a benefit also, because they are one of the biggest employers in Munich, in the magnitude of 10,000, 20,000 employees. And of course, this also creates wealth in the city" (interview, Munich green engineering consultant).

The interviewee continued:

> "The benefit for the people is the *Stadtwerke,* the 100 per cent idealistic model is really the biggest benefit for the people. It creates jobs in the city. It stimulates so many things, so much commercial activity which is local in the city, they are all tax payers to the city and… the goal must be that as little money and wealth flows from here to somewhere where you don't control it" (interview, Munich green engineering consultant).

The joint services of the SWM not only offers a single service provider for residents but could also offer opportunities to external companies involved in data analytics and could provide an infrastructural underpinning for technological developments towards 'smart' cities. One interviewee, when asked what he thought infrastructure integration was, outlined his desire to see:

> "…an information platform for the entire region. To have this totally integrated platform to have the information about what's going on in the city. Information from all over about the mobility, about the energy, about the water, everything I need should be in this platform. Right now, we are starting to develop things in exactly this way. All of the small things you do right now puts everything together" (interview, Siemens official).

One way to achieve this would be to have one customer facing social organisation while maintaining the divisions between the departments in the back office:

> "There are synergies, there are hidden synergies, let's say in the invoicing system, they have the same data systems… in principle the customer interface, the customer centre, could be also responsible for water, energy, gas, so I think there is, you know, a regulatory or legal barrier to do this… the operations, the company itself, yes has to stay separate, but there is another synergy for the city… if we have a construction on the road, any maintenance work on the road, we ask each single entity, do you have a plan to renew your water supply lines, your waste water, your electricity lines, is there anything you want to do in the next 20 years, because if so, do it now. You will not get the permission to reopen the street after 5 years, when we do it now" (interview, Munich green engineering consultant).

### 6.2.2 STRATEGIC URBAN PLANNING

The second theme of infrastructure integration that arose during the interviews is the importance of urban development masterplans and planning strategies developed by the City of Munich. These strategy documents act as templates for urban growth, deliberative governance arrangements and infrastructural planning for the city, yet remain flexible enough for officials to seek innovative solutions to problems as they arise. The success of urban planning within Munich is arguably due to the 'integrated' nature of its land use and transport planning (Hale 2010). While city authorities use advanced transport analytical tools and place an emphasis on sustainable and high-quality infrastructure projects, it is "only through recognizing the 'truly integrated' nature of urbanism and planning in Munich that we can fully account for the city's strength on a range of strategic questions" (Hale 2010: 588). As one interviewee said:

> "Not everyone in such a large authority has an integrated approach like we have it here. Everyone says you have to coordinate and cooperate and so on, but in reality, it is sometimes a little bit difficult. In Germany, you need patience, and cleverness, and you must know your own responsibility and the responsibility of the others, otherwise you won't win" (interview, City of Munich planner).

Part of the success of urban planning within Munich is the extent of the cooperation between the various city and state departments and the discourse on social provision and urban equity (interview, City of Munich planner). Another part is the level of strategic planning and discussions that occur between the city's departments. Several respondents discussed the importance of the 'Munich Perspective' development concept, which acts as the urban development strategy that has underpinned city growth since 1998. It is described as a "strategic, proactive urban development concept" that promotes a cooperative and communicative process of "managing uncounted interdependences in an open field of actors of the civil society, the market economy, the different levels of the political-administrative system and the democratic decision process" (Thierstein and Reiss-Schmidt 2008: 1). The strategy was initially developed to pursue policies of 'internal expansion' within the already built-up city centre area to counteract urban sprawl. The concentration of advanced knowledge-intensive industries within Munich has led to a diffusion of the associated supply, residence and leisure functions that are placing pressure on the city's infrastructural networks (Lüthi et al. 2007). As one commentator described the scheme:

> "Instead of radical re-development, building city highways and concrete block settlements, priority was given to the functional mix of quick/swift/fast planning of infrastructural areas such as kindergartens and schools, recreational and green areas and shops. The city planners aimed at giving the citizens back their quality of life. When you look at newer residential areas today, such as Munich Riem or the Ackermannbogen, it appears that they were successful" (Bayern Design 2014).

Since its initial creation, the Munich Perspective has grown to encompass all areas of urban development, although it remains a flexible set of guiding principles for development rather than a rigid and fixed blueprint. In 2013, for example, the Munich Perspective consisted of one overarching guiding principle ('City in Balance'), four strategic guidelines (such as Open Atmosphere and

Attractive Appearance, and Foresight and Cooperative Management) and 16 thematic guidelines on issues such as employment, education, ecology, housing, competitiveness and social community politics (City of Munich 2015). One key aspect is the focus on 'compact, urban and green' development priorities under the internal expansion concept, which has resulted in non-sustainable, car-dependent exurban development effectively being ruled out (Hale 2010). One interviewee discussed the rationale behind the Munich Perspective was to integrate various forms of land use:

> "In Munich the aim is that the quarters are mixed, so we want to avoid quarters with only living, only working, only retail, so they should be mixed. That is one aim from the Munich Perspective" (interview, City of Munich planner).

This document allows staff from a number of different city departments to work on similar themes. One interviewee from Siemens, when discussing the interactions between the City of Munich and Siemens and the links with the Munich Perspective, said:

> "The different departments of the city have the same themes: they are all talking about mobility, all talking about the buildings, and so on. It doesn't matter if it's the Department of the Economy or Business, or the planning department. Sometimes they have the same themes and there are many, many, things coming together with the different kind of projects they have" (interview, Siemens official).

It appears this form of strategic planning allows city officials to maintain a degree of control over urban development. Large scale projects are pursued only when high-level strategic planning objectives have been met, and city officials retain a high level of control over building regulations, project planning and infrastructural provision. The Munich Perspective encompasses all city departments, including the transport subsidiary MVG – which manages buses and the tram network – and SWM, which has aligned the strategy alongside its own investments for a carbon-free city. While other cities often use similar rhetoric in terms of sustainable development, Hale (2010) found:

> "Few are actually achieving these outcomes to the same extent, however. It is the researcher's contention that Munich's institutional and industry competencies allow it to deliver large-scale projects that make a substantial impact in delivering sustainable locations and the sustainable metropolis. Other cities without these competencies in mega-project conceptualization and delivery seem to be left hoping that, in planning and development terms, a large number of small projects will be able to contribute 'a whole that is greater than the sum of its parts'. Rarely does this seem to occur" (Hale 2010: 589).

The Munich Perspective allows city officials to retain considerable control over private development within the city. For example, officials attempting to develop a media-focused business park in the Westend city quarter – known as the *Medienfabrik*, or Media Factory – sold the land to investors with the condition that only media-orientated firms could use the premises (Streit et al. 2010). These innovative regulations force the developers to cooperate on a strategic level with local authority officials, allowing city authorities to maintain a degree of control over urban planning and infrastructural provision. The Central Railway Lands mega project offers one example of how the Munich Perspective framework operates.

The Central Railway Lands can arguably be described as the exemplary project under the Munich Perspective development concept, encompassing the 'compact, urban and green' motto. The Central Railway Lands is 170 hectares and is one of the largest urban developments underway in Munich. The site is 8km west of the city centre and the redevelopment project consists of six separately planned areas. Once finished the area should house 16,000 residents and workplaces for 19,000 people, alongside sports facilities, schools, shopping areas and green spaces (Thierstein and Reiss-Schmidt 2008). Early discussions in redeveloping the site included representatives from property development companies, consulting firms, and a multitude of city departments. It was the large mix of city departments engaged in early discussions – such as the departments responsible for urban planning, building codes, health and the environment – which arguably led to the absence of disputes during the planning process (Hansen 2013). Cooperation between the City of Munich and the railway operator Deutsche Bahn AG (which originally owned the site) is regulated by its own framework agreement and underpinned by a collaborative project management committee. Key objectives from the Munich Perspective were integrated into the plans from the outset: 30 per cent of all residential floor space was designated for social housing; thousands of trees were planted or are due to be planted in each of the six sites; biodiversity goals for the site – which had largely remained fallow for two decades before the redevelopment – were factored in as planning conditions; public transport and cycleways were used to integrate the area into the wider city region; a series of workshops, competitions and community meetings were held as part of Munich's policies towards deliberative democracy; and the city centre tram network was extended to the nearby Pasing train station, which also benefitted from the creation of a new central bus station. As Hansen (2013) outlines:

> "This process of discussion between city departments, local political committees, citizens, and the property owners/investors ended with a final meeting where decisions and plan adaptations were announced. Afterwards planning firms revised the planning concept according to the results of the participation process. The final plan was presented to the public in an exhibition with a presentation at the end of 2004. In the further process other bodies of public affairs were included, the project was approved by the city council, and the formal public participation process was conducted in order to prepare the resolution of the legally binding land--use plan" (Hansen 2013).

While the Munich Perspective has arguably been successful in integrating the various departments within the city and aligning them with sustainability goals, there are a few difficulties with the approach. The proliferation of goals and outcomes has meant the strategy suffers with public relations, making it difficult to communicate successful outcomes to the wider public. The large number of participants in the strategy, while in many ways a key strength, also causes the "fragmentation of power and planning capacity, different rhythms on decision making and philosophies between core cities" (Thierstein and Reiss-Schmidt 2008: 12).

### 6.2.3 THE PUBLIC PRIVATE INNOVATION MILIEU

The third theme of infrastructure integration that emerges in Munich is the innovation milieu arising from the mix of public and private sectors and the cooperation and crossovers between the diverse range of actors. It is significant that knowledge-intensive innovation companies are based in Munich and the partnership working arrangements between them and the local authority allows for innovations in transport policies, technologies, urban planning strategies and climate protection goals. The positive discourse surrounding the concept of infrastructure integration somewhat reflects the large number of high-tech companies located in the city. One interviewee from Siemens said:

> "The city of Munich is on a high [strategic] level, [they want to] be one of the first cities who steps forward, who goes into the future, and Munich wants to tell other cities 'you can do it like me, you can do it like this'. That's what they have in their mind and what drives them. That's very good because we have to keep up, Siemens has to keep up with these visions. When working with municipalities in Munich, I'm always further along than other municipalities and in my mind, or in the mind of Siemens, it keeps us further on too" (interview, Siemens official).

The abundance of knowledge-intensive businesses and the cluster of high-tech companies in Munich appears to create an innovation milieu that city officials and businesses can tap into to achieve policy outcomes in transport, environment and social equity. Many of these companies are keen to collaborate with the local authority in delivering the aims outlined in strategic documents such as the Munich Perspective. One interviewee said:

> "The vision of the City of Munich is coming from the city. The city has said, 'OK that's the vision that we have', and then we try to make this work with our portfolio, and to give them ideas, and maybe 'OK if you want to reduce CO2 or something, then we can help you with this and this portfolio', so we have different kinds of tools, different kinds of workshops, and we are working together with the city" (interview, Siemens official).

Part of this collaboration involves the construction of high-quality corporate headquarters that can be showcased to the world by both the company and city officials. The new Siemens headquarters, for example, was opened in June 2016 and contains 45,000 square feet of office space for 1,200 employees. The building "meets the world's highest sustainability standards" with a publicly accessible ground floor that creates a pedestrian corridor for residents and visitors to "stroll between the Bavarian capital's historic centre and its museum district" (Siemens AG 2016). While the new building was funded by Siemens, the architectural design was completed in collaboration with Munich city officials through an open competition launched in 2010. One interviewee spoke of the importance of the collaboration between the public and private sectors:

> "This partnership… I think right now it's developing, a lot, because Siemens needs the understanding of the city and the city needs the understanding of Siemens. Like BMW: if you don't have a vision in Munich to develop electromobility cars, there is no chance for BMW to make it" (interview, Siemens official).

Another example of this innovation milieu is the flexible and creative working practices at BMW's headquarters in Munich. During the 2008 recession, the company collaborated with the German government to transfer many workers to a four-day working week instead of terminating their contracts to save costs. The company agreed to pay wages for four days while the government paid 80 per cent of the wages for the fifth day, keeping unemployment within Munich low. As one report stated:

> "The government benefited by not having to pay a full week's unemployment benefits to terminated workers, and the company reduced its wages bill while retaining its skilled workforce" (Avery and Bergsteiner 2011: 13)

The innovative forms of institutional governance within Munich (constantly evolving forms of deliberative governance, the mix of public and private sector actors, and the concept of the city as a holistic provider of services) can lead to highly individualised and context-specific solutions to often complex problems. One example of this in terms of infrastructure integration is the Inzell Initiative.

#### 6.2.3.1 THE INZELL INITIATIVE

The Inzell Initiative is a public private discussion group formed during discussions between the City of Munich and BMW in 1995. The original aim was to discuss traffic problems and to find solutions beyond traditional political mechanisms while remaining outside the formal administrative and political process (Baumann and White 2011). The first group of (secret) meetings were held in the upper Bavarian skiing resort of Inzell and involved representatives from politics, economics, science and the city administration hoping to overcome political and ideological differences and to "solve traffic problems together" (Mailer et al. 2014).

Conflicts had occurred between motoring groups and the city in the 1980s and 1990s with the city council taking offence at attempts by companies such as BMW to interfere in strategic planning (Hajer and Kesselring 1999). The conflicts came to a head in 1995 when two competing citizen initiative referenda were held – one proposing to construct three new tunnels around the inner city, the other proposing to use the money for childcare services, general improvements to public services and public transport infrastructure enhancements. Despite there being clear majorities for the passing of both initiatives (Hajer and Kesselring 1999) the tunnel proposal won by a few hundred votes, leading to its implementation against the wishes of the city administration. One interviewee said this incident led to the creation of the Inzell initiative:

> "There was confrontation between BMW and the local authorities, and then one day they said 'why always confrontation? Let's have a look not to the differences but to the common goals and common projects'. That's the idea of the Inzell initiative. And since they started in this way we have had success. It's just been renewed because the new mayor thought 'should we end this project', but the City of Munich and the leaders of BMW said 'no, we want to continue'. It's an interesting project. We have a lot of actors and active institutions in the city and the region. But I always say in the real sense of the word, it's a private public partnership, but it's only a

partnership on the discussion level. We don't have investment projects come in" (interview, City of Munich transport official).

As Hajer and Kesselring (1999) argue:

> "Among experts, the meetings at Inzell are regarded as a major success. Never before did Munich achieve similarly broad co-operation among actors from such a variety of backgrounds and dealing with such highly contentious political issues as traffic. What is more, the co-operative effort allowed for a conceptual renewal in a very short period of time. The Inzell process gave rise to a new discourse-coalition: it cut through the existing formations of interest and problem perception. The redefinition of the problems involved, and the accompanying creation of new perspectives for the various interested parties, were seen as a turn for the better by most participants. In this sense the Inzell meeting gave way to new networks that cut across the various municipal departments and included various groups from business and industry as well as experts from the university" (Hajer and Kesselring 1999: 11).

There are 11 main issues now being researched in the Inzell initiative, outlined in Table 7.2

| **Main aims of the Inzell platform** |
| --- |
| **1. The structural development of residential areas should be geared to the public transport network.** |
| **2. The closer to the city centre, the lower the proportion of automobile traffic should be.** |
| **3. Through-traffic should be kept away from densely populated areas.** |
| **4. Those who wish to calm traffic flows in residential areas must concentrate traffic on the main arteries.** |
| **5. Cooperative traffic management enables the performance of the transport systems to be boosted and Improved.** |
| **6. Local public transport has priority.** |
| **7. The park-and-ride system as a means of networking different modes of transport needs to be improved.** |
| **8. A parking-space management concept must be drawn up for the city.** |
| **9. In the individual transport area, commercial and trade traffic has priority.** |
| **10. Freight transport is to be optimized by promoting logistic systems.** |
| **11. Traffic is to be avoided by encouraging car owners to carry more people in their vehicles.** |

**TABLE 6-2 THE AIMS OF THE INZELL PLATFORM**

One interviewee said the discussions involve:

> "…not only people, citizens, but also firms, different cities and regional planning, and the state of Bavaria. I don't know such an initiative elsewhere in Germany. It's special to Munich" (interview, City of Munich transport official).

The Inzell initiative represented a shift "in the way stakeholders interacted, resulting in cooperation rather than confrontation, and in the adoption of consensus views rather than polarized positions" (Baumann and White 2011: 31) and it has become a key example of what is described as

"collaborative stakeholder dialogue". Issues are discussed in meetings held every one to two months and solutions can be proposed to the council for implementation in what is described as a "pre-parliamentary or pre-political platform" (Baumann and White 2011: 32). One important institutional change has been the creation in Munich of a mobility management department which consults new Munich residents on their transport options as well as providing education for children and senior citizens. The Inzell format has been so successful it is now being used as a platform to create the Vision Mobility 2050 for the city region – a strategy to discuss transport issues over the next 35 years. However, the very concept of the round table discussions between BMW and the city of Munich has been described as a "neo-corporatist practice of policy-making" that takes place outside of traditional democratic arenas (Hajer and Kesselring 1999). Hajer and Kesselring (1999) add:

> "…it pays lip-service to the new democracy, being constructed in public discourse as a 'round table', just as it is promoted as an 'open' dialogue between the city and industry. Yet in actual fact this round table looked remarkably similar to the well-known two-sided tables of corporatist practices which allowed industry privileged access to government. In the case of Inzell, industry is in a position to exert considerable influence, not only in terms of framing the issue of mobility but also in suggesting strategic solutions to the 'problems'" (Hajer and Kesselring 1999: 14).

Discussions are kept internal, excluding the public from any input in the decision-making process, who are instead informed of decisions once they are taken and promoted externally (Mailer et al. 2014). In some respects, having a company as large as BMW involved in city region discussions is a clear advantage:

> "It's very interesting, I think it's a very good thing for a city like Munich because we have that big player with much influence in many places, many important places where decisions are made and it's better to work together with BMW than to work against BMW" (interview, City of Munich planner).

The cooperation between city leaders and BMW has created a regional partnership which seeks to lobby central government for infrastructural improvements that would benefit both Munich and BMW. The multi-national company has plans to expand its research centre in the north of the city, however plans to extend the public transport network to accommodate the increase in employees requires more than just city approval:

> "Now we have this research centre of BMW, with 20,000 employees, and the architects and planners of this new enlarged centre said we need a new public transport station in the north. And we have wanted this for the past 20 years. But now BMW goes to the state of Bavaria, and says they should build it… if BMW wants to have a date with the Chancellor of Bavaria, they will have it. They can't change the normal rights that cities and so on have, [but] it's clear they use their influence, that's the reason why they do this" (interview, City of Munich transport official).

BMW is not involved in the Inzell initiative for altruistic reasons ("certainly they want to sell their cars, it's clear, but they don't want their cars to have to drive around in the inner-city area", interview, City of Munich planner). One interviewee discussed the potential problem of having such a large car manufacturer involved in city planning:

> "We want to reduce car traffic, that's very clear, we want to have a city where you can cycle very well and walk very well and it's not so necessary for us that you go by car very well. We have BMW in our city, and for that there are lobbyists certainly, and our Lord Mayor is very proud of having BMW in our city, we can't say we want no cars in the city" (interview, City of Munich planner).

Another interviewee from the nearby town of Ingolstadt – home to Audi's production plant with 35,000 workers – outlined how city officials can become overwhelmed when faced with such large manufacturers: "the wishes of Audi are the orders of Audi" (interview, Bavarian state councillor).

The Inzell Initiative emphasises the incremental nature of German policy making that is prevalent in much of the academic literature. When the existing power structures began to break down in transport discussions and led to confrontation and conflict between the city and major manufacturers, Inzell demonstrated that the consensual German model can work – regular dialogue was created between public and private operators, early and frank discussions over potential flashpoints were routinely held, and the joint development of urban plans has led to cooperative partnership working between the public and private sectors. A negative aspect of this can be seen in Hajer and Kesselring's claim that Inzell represents an ecological modernist desire for technological solutions to urban problems (Hajer and Kesselring 1999). Inzell also represents a danger to the democratic process with key decisions taken behind closed doors, away from external scrutiny and with little input from citizens. Engineers can often focus on practical solutions without regard to citizen experience or voters who are affected by the decisions taken by others. As is often the case "'good' (that is, democratic) practices do not automatically produce 'good' (i.e. more sustainable) results" and in certain cases they can be counterproductive (Hajer and Kesselring 1999: 2). Early discussions with other technology companies such as Siemens demonstrate the potential for this sort of partnership to evolve further in the rapidly growing 'smart' city debate, with Munich's desire to develop its industry to become a world leader in easily exportable technological solutions to civic problems.

## 6.3 Issues Impacting Upon Infrastructural Integration

There are two main issues associated with the Munich environment that impact upon infrastructure integration. First, the decentralised governance networks operating within Germany allows space for pockets of experimentation and innovation to emerge through the subsidiarity offered to small districts and local authorities. Cities and districts have a degree of autonomy that can lead to innovations in policy making and many decisions on infrastructural provision are *actor-led*, in that motivated system builders (Hughes 1987, Hughes 1983) can operate with a flexibility not offered to equivalents in other cities or countries. Second, there are several regulatory issues that restrict the actions of publicly-owned utilities, mainly European liberalisation laws that prevent forms of cross-subsidisation between utilities, in ways similar to the judicial splintering occurring within Seattle. I will examine each of these two issues in turn.

### 6.3.1 Actor-led Innovations: Munich's Systems Builders

While the consensus-seeking political structure of the city region of Munich may, in theory, make it difficult to secure agreement on controversial large infrastructure projects, in practice the lack of top-down authority has created the conditions for certain forms of infrastructure integration to flourish. Constraints on centralised city-region control (tamed by strong local democracy) has opened up spaces for a variety of actors to be able to promote their own schemes, with leaders and networkers who are not perceived as dominated by self-interest to rise to the forefront. There are actor-driven strategies that allow for integration to occur and several academics have cited a hypothesis:

> "…based on the premise that overcoming institutional fragmentation as well as creating functionally overlapping governance structure and achieving more consistent metropolitan governance requires *networkers* and *consensus facilitators* who are seen as *neutral brokers*, and who have the trust of others in a metropolitan area, that is, who are not perceived as (purely) self-interested actors who play their own game" (Heinelt and Zimmermann 2011: 1187).

While the Inzell Initiative offers an example of how corporate actors can become involved in city governance networks, the Limux project – a ten-year project to change the city's IT systems – is evidence of how determined individuals within the local authority can influence infrastructural decisions.

#### 6.3.1.1 The Limux Project

The motivation for the Limux project was to shift the city's IT systems away from the closed Microsoft Windows system and towards open source platforms. In 2003 the city began preparations to migrate its desktop computers away from Microsoft Windows to the GNU/Linux platform, and although the project has been successful in cutting IT costs, the main motivation for the shift was to avoid problems with technological lock-in. The project has been driven by IT managers within the city council who believe the project could spur technological innovations within the city. The deputy coordinator for the project, Florian Schießl, outlined the primary motivation to the project:

> "Microsoft has shown us what it means to be dependent on a vendor. Until 2003, the city was using Microsoft Windows NT 4 across the board, and was by and large satisfied. When Microsoft decided to end the support for this operating system, this meant that hardware and important procedures would eventually stop working. It was from this experience of being totally at the mercy of an external party that we wanted to take the road to more independence" (Gerloff 2010: 1)

The city estimates the shift to open source has saved the administration €11 million in software licences, hardware upgrades and training (Essers 2012). However, a report into the shift states that the desire for change is not purely financial:

> "Munich's use of free software is clearly strategic. Rather than spending its money on buying software licenses, the city only pays for adapting programs to its own particular needs. This is a degree of freedom and flexibility that users of proprietary software usually do not enjoy. Open source software and open standards make it possible for SMEs to fully participate in the competition for the city's business" (Gerloff 2010: 12).

While there have been key benefits to the city of Munich the project began not as a simple IT project, but as an independence project with IT specialists within the city council receiving political backing from officials attempting to create a Munich-specific IT culture. One interviewee, when describing the project as a 'change project' rather than an IT project, said:

> "That's something exceptional for us, because the motivation was purely political…. The Green Party is trying to do that in some other cities, in Hamburg, in Berlin, but they haven't got the political backing, like it was here" (interview, Munich IT official).

The freedom given to the project managers is a key factor in allowing the Limux scheme to succeed:

> "There were no boundaries. If we saw that there was something that had to be done, we could do it. There was nobody holding us back. Everybody was lucky that someone could care about it" (interview, Munich IT official).

The project offers international advantages to the city:

> "This courageous decision is now paying off. Munich has become an internationally recognised example for the strategic use of free software, attracting commensurate attention from other public administrations as well as from industry and academia… Along with the overhaul of its IT infrastructure, the migration will leave Munich not only with an efficient IT system, but also with the privilege of independent decision making thanks to open source software" (Gerloff 2010: 12).

The Limux project demonstrates the capacity of the city to innovate radically in its technological decisions, seeking to develop an alternative software suite once the disadvantages to long-term technological lock-in became clear. Although the project took more than a decade to complete the city has demonstrated its desire to become independent from often unreliable (and uncontrollable) private sector providers, to use its considerable resources to retain IT spend within the city region and to encourage local SMEs and start-ups to develop software and solutions without the constraints imposed by large US technology companies. It is somewhat ironic that a city that has gone to such great lengths to develop its own independent IT infrastructure would be home to companies pushing 'one-size fits all' smart technological products to other global cities. While the Inzell discussions can be seen as the incremental innovation key to German capitalism and the (potential) further neo-corporatisation of urban life, the Limux project perhaps demonstrates the ability of determined and single-minded 'system builders' who wish to change organisational culture and direction (Hughes 1983). The shift to an open source IT platform is a radical departure from the standard technological pathway that is occurring globally – a single city-based operating system is a risky venture given the levels of uncertainty and potential for failure. Developing an independent and open source IT infrastructure, outside the traditional Windows architecture, is possibly one of the most innovative projects a city can undertake. Yet the Limux project has strong political backing,

despite pressure from Microsoft to reverse course, and has become a global example of how cities can choose their own independent course.

### 6.3.2 The Regulatory Structure

The second issue impacting upon infrastructure integration within Munich relates to the regulatory environment the city operates within. With the incremental nature of consensus-seeking implicit within German democracy it may appear difficult for policy-makers within Munich to make large innovative leaps. However, the strict legal and regulatory separation of the SWM from the City of Munich, and the European legislation that has split the utilities within the SWM into separate legal entities, does allow for infrastructural projects to proceed largely outside the political sphere. The independence and engineering authority offered to SWM, along with its transition into a competitive enterprise that provides services alongside its private counterparts, allows it to take decisions on infrastructures largely outside of the political arena.

By taking advantage of liberalisation policies across Europe (motivated at the European level by a desire to create pan-European integrated markets in energy, transport and telecommunications) and despite a trend in Germany at the turn of the century towards privatisations and outsourcing, the city-owned SWM is one of the strongest and richest *Stadtwerke* in the country. The SWM has been able to spread its operations far beyond the borders of the city in which it is based. The SWM has taken the "We are Munich" identity and culture and used it to its full advantage and many projects are sold on how many jobs will be created in the city, how they will help towards wider environmental goals and on a general dislike for the Big Four national energy companies. The SWM is not just a city-based utility: it has become a market leader in many of its fields. The SWM maintains its role is to "remain a strategic guarantor of economic prosperity and quality of life in Munich and beyond (SWM, 2012)" (quoted in While et al, 2013) and is undertaking a dual strategy of 1) providing a viable, well-funded and attractive service alternative to other private providers, and 2) expanding its business by partnering with private utilities across Europe in large renewable energy projects, to both increase its own renewable output and to attract customers from outside the city boundaries. The SWM acts as a parent company to 23 fully consolidated subsidiaries such as the energy and water utilities, the M-Net telecommunications company which is rolling out its own parallel fibre optic network across the region, and the regional transport operator MVG. While integration within the SWM is, and always has been, cross-sectoral in terms of supplying Munich with the infrastructures needed for economic growth, since the turn of the century the SWM has shifted its focus to projects throughout Germany and wider Europe in an attempt to provide Munich residential homes, subways and trams with 100 per cent renewable energy by 2025. A press release on SWM's Renewable Energies Expansion campaign outlines the aim:

> "Projects in Munich and the surrounding area take priority for SWM. For example, SWM is currently operating 22 photovoltaic plants and is involved in one photovoltaic plant here. The portfolio in Munich and the surrounding region also includes 13 hydroelectric plants, a biogas processing plant, two geothermal plants (one of which generates only heat) and a wind park. Other solar, wind, hydroelectric and geothermal plants are on the drawing board. Nevertheless,

SWM is unable to generate as much green energy here as the city requires, as the regional potential is limited. It is therefore participating in projects across Germany and Europe. Within Europe, SWM selects and makes use of the most suitable sites in terms of energy density and economic viability on which to build plants for generating green energy. This potential will safeguard Munich's energy future" (SWM 2016)

While many cities have been forced by European liberalisation policies to open up their own utilities to private competition or have acted to sell off their public holdings altogether, the SWM has taken a different approach by commercialising its operations and acting as a competitive organisation to compete directly with the large energy and telecommunication companies. The SWM's dichotomous nature as a competitive organisation and a public sector back-stop, a major continental infrastructure provider and a cultural and social affiliate of the city of Munich, offers a number of advantages, outlined by one interviewee:

"What is very important in this context is that there's still an open market, that you have choices. I'm an environmentalist to a large extent. I'm driven by the basic idea of decentralisation, this is something I like, because it creates more flexibility in the general process, and to have a company with no choice would be a big danger. So, this animal only behaves brave and well because there is competition from the outside to benchmark, and in the past before the deregulation of the energy market we had this animal already, but it didn't work very well, because they said 'you have no choice, we can do whatever we want, we can demand whatever we want you to pay to us, you have to accept our technical hurdles and so on'. The customer always should have the choice, I'm totally convinced on that, and the *Stadtwerke* itself must benchmark itself on its quality against other players" (interview, Munich green engineering consultant).

European competition laws (such as directive 96/92/EC) designed to prevent forms of cross-subsidisation across infrastructural sectors has led to the SWM facing a form of judicial splintering similar to that found in Seattle: the energy utility cannot be used to fund water projects or general city-funded projects such as transport or housing. One interviewee said that despite many *Stadtwerke* employees being based in the same building "the company that looks at the electricity grid has to be in a different room, and has to be in a different company" (interview, Augsburg energy official). When asked if being in the same building offered advantages the respondent added:

"Not really, it would be an advantage if we can work together with the grid company, but it's forbidden to work too close together. We have only one project where it's a bit possible to work closer together, there's a smart micro grid, but it's only possible because we have a joint research project, but normally it wouldn't be possible. It's not possible to work too close together with the energy companies. It can be a bit complicated to work together on some projects" (interview, Augsburg energy official).

While in Seattle the splintering has led to utilities being separated in legal terms only (joint projects are still carried out, albeit subject to compliance with the accounting laws) in Munich the sectoral splintering has allowed SWM to engage in a policy of geographic, European-wide and sector-specific integration. The SWM does not fund water projects or contribute towards housing goals, however it has rolled out its energy operations far beyond the borders of Munich, taking advantage of the integration of European energy markets to increase the level of renewable energy provision for Munich customers. This includes the construction of the 48-turbine Sidensjo wind park in Sweden in

collaboration with RES subsidiary Nordisk Vindkraft; the purchase of three French wind parks in Fillières, Chaussée de César Sud and Dehlingen; construction stakes in offshore wind parks in Germany (Global Tech I and DanTysk) and the United Kingdom (Gwynt y Môr); and the construction of the Andasol 3 solar thermal plant in southern Spain in a joint venture with RWE Innogy and several investment holding companies (for a range of SWM's European energy holdings see Figure 6.2 and Table 6.3).

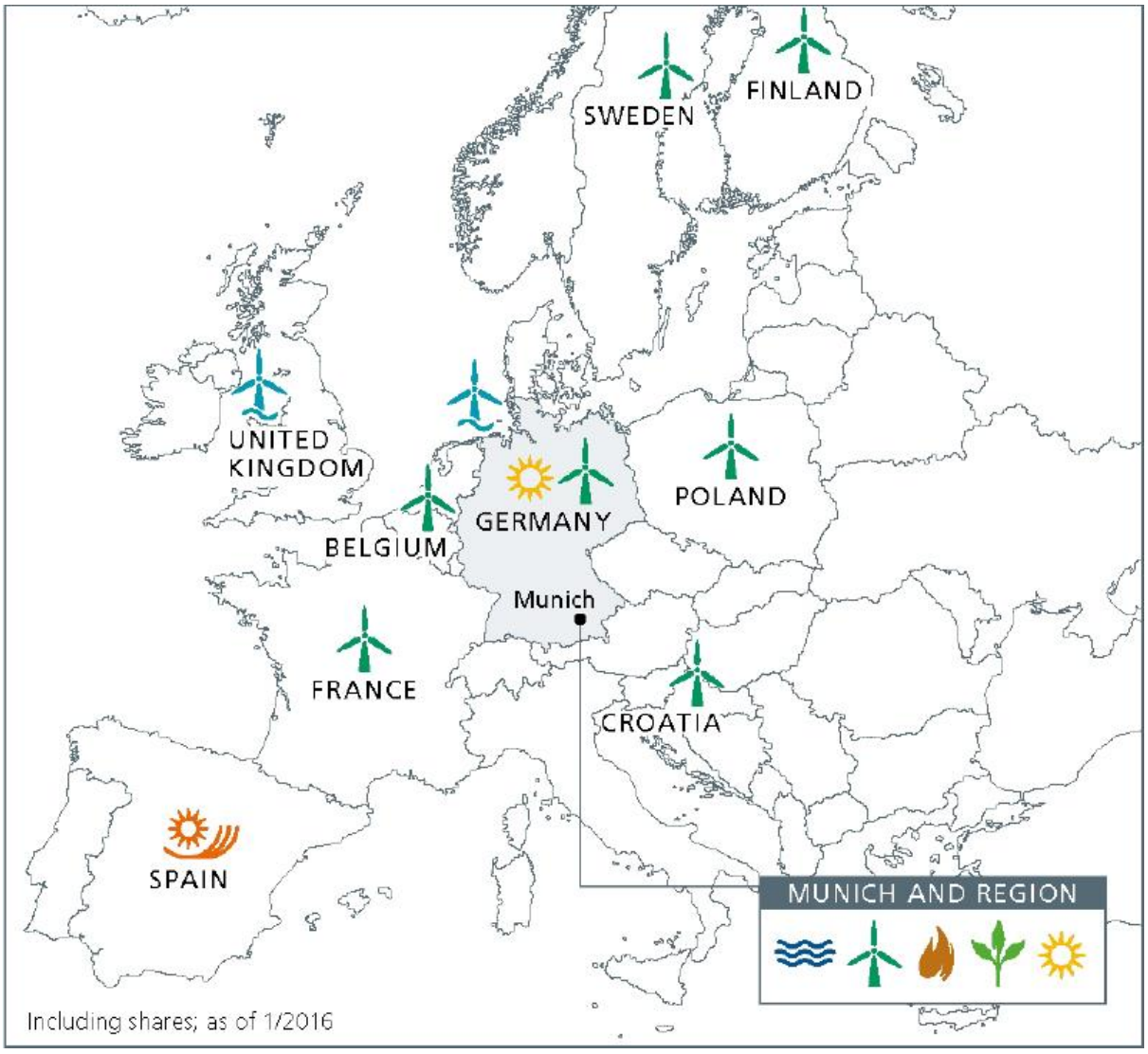


**FIGURE 6-2 SWM'S EUROPEAN INVESTMENTS (SWM 2016)**

| Munich and Region | Germany | Europe |
|---|---|---|
| 13 hydropower plants | 3 offshore wind parks (North Sea, one under construction) | Offshore wind park (UK) |
| 1 biomass plant | Oneshore wind parks (Brandenburg, North Rhine-Westphalia, Rhineland-Palatinate and Saxony-Anhalt) | Onshore wind parks (Belgium, Finland, France, Croatia, Poland, Sweden) |
| Wind power plant | 2 solar power plants (Bavaria and Saxony) | Parabolic trough power plant (Spain) |
| 23 photovoltaic plants | | |
| Geothermal plant | | |

**TABLE 6-3 SWM'S INVESTMENTS IN GREEN ENERGY ACROSS MUNICH, GERMANY AND WIDER EUROPE.**

The SWM has also begun to integrate smaller decentralised generation plants into its own virtual power plant network, allowing small operators the ability to sell their energy on national and international markets. The *M-Partnerkraft* product, created in collaboration with Siemens, "enables operators of smaller generation plants to join SWM's virtual power plant and thus gain access to the regular electricity markets or commence direct marketing of renewable energies" (Stadtwerke München GmbH 2015: 44).

While the European liberalisation rules prevent cross-subsidisation across sectors they do not prevent other *Stadtwerke* organisations from working with each other in partnership. Since the turn of the century there has been a growing trend towards inter-municipal cooperation between publicly-owned utilities. The creation of the M-Net telecommunications company is one example and was created to address a perceived gap in Bavaria's broadband network. The system currently supplies fixed-line communications to 50 per cent of Bavarian homes. The SWM owns a 60 per cent stake in M-Net, with other shareholders comprised of the *Stadtwerke Augsburg Energie*, *Stadtwerke Erlanger* and *Allgau Uberlandwerk* – which is itself a limited company owned by several cities and municipalities. When asked if the inter-municipal ownership structures operated by such companies presented any problems, one interviewee from Ingolstadt – whose *Stadtwerke* is 49 per cent owned by the city of Ingolstadt and 51 per cent by the city of Mannheim – said "it's working fantastic, no problems, we are content" (interview, Bavarian state councillor). Another interviewee outlined the multitude of ownership combinations at work within Germany and discussed the benefits of regional cooperation:

> "There are hundreds or thousands of endless combinations of this. Munich, accidentally, is the perfect case. [Regional planners can] approach the *Stadtwerke* and say, 'hmm Munich needs a new power station, how about Augsburg do you have any demand on heat or electricity, we can offer this or this', so they collect the interest of various players and then they build a new power station maybe, or a new wind park" (interview, Munich green engineering consultant).

The *Stadtwerke* is also able to advertise its services to city residents:

> "It's not a guarantee that people stay with your local energy suppliers, it heavily depends on who is owning it, who is steering it, what are the goals of this company. I always ask myself, why is the *Stadtwerke* doing so much advertisement in the city, everywhere you see the *Stadtwerke* logo,

> welcome to our nice city, why? They have 95 per cent market share, but you need to identify yourself with this, and if you look at the advertisement its always showing the wonderful sides of Munich, and you feel connected to this and say 'OK this is my company'" (interview, Munich green engineering consultant).

The commercial pressures introduced into the energy market are forcing the SWM to improve its existing services in order to retain customers, while simultaneously driving the utility to attract customers nationally through an online portal – the commercial pressures are, as one interviewee claimed, a way to 'tame the beast' (interview, Munich green engineering consultant). While the regulatory pressures prevent cross-sectoral forms of organisational integration, they do work towards furthering goals of intra-sector integration, combining energy schemes within Bavaria, allowing energy generators to collaborate and share risk while also driving the development of renewable schemes elsewhere. In many ways, the commercial pressures introduced into the German energy markets have been a success in Munich, and the satisfaction and customer retention rates – despite the availability of cheaper providers – allows the SMW to demonstrate how Munich's socio-political culture and identity can influence citizen behaviour and infrastructural choice.

## 6.4 Discussion: Introducing Innovative Integration

As in Seattle, infrastructure integration within Munich is context-specific and a result of the institutional environment of the city. The lack of an ideological preference towards public or private provision allows for a form of evolutionary infrastructure integration similar to that seen in Seattle. However, while integration arises somewhat organically within Seattle as a result of the daily interactions of diverse actors operating within the city authority (integration occurs when it is the obvious solution to complex problems) in Munich infrastructure integration is more widespread throughout the urban discourse and extends beyond the city authorities to include the private sector. As a result, infrastructure integration within Munich is seen as an end goal in itself, and what is important is the ability of the city to innovate and change direction when existing governance forms begin to break down. This creates a form of integration which I describe as *innovative* integration, or rather, infrastructure integration occurring *as a result of the innovative processes* inherent within the city's institutional structure. There are two aspects to address in relation to the extent of what I term are *innovative* forms of infrastructure integration.

First, is the extent that infrastructure integration has been both enabled and constrained by the changing institutional context over the past few decades and the ability for local authorities within Germany to adapt to the changing environment. The federal German model of governance offers a degree of autonomy to local authorities to manage their own infrastructural concerns. As outlined in Chapter 3, the wave of New Public Management techniques that were adopted in German municipalities during the 1990s (often imposed by European legislation and leading to policies favouring privatisation and liberalisation) have evolved into new forms of municipal provision over the past few years – between 2007 and 2012, 60 new *Stadtwerke* were created under a growing culture of re-municipalisation while more than 190 contracts for energy networks were returned to the public sector (Hall et al. 2013). The shift away from public provision, towards liberalisation, and

now back towards a re-municipalisation of services (Wollmann et al. 2010b) has arguably been facilitated by the degree of autonomy offered to local administrations within Germany. The German conception of an 'organicist' state, coupled with a form of 'pragmatic municipalism' (Lorrain 2005) provides the theoretical underpinning for devolved local administration. While there are tensions between the federal, state and municipal levels of governance, cities and local administrations retain the power to manage their own infrastructures, to adapt them according to changing environmental and economic circumstances and to tailor specific solutions to their local surroundings. This is evidenced through the creation of the Bavarian-wide M-Net telecommunications company to compete with private providers, the Limux IT project designed to capture IT-focused growth revenues and to provide stability and security for city IT projects, and the specialised governance frameworks associated with individual urban development projects within Munich. The decentralised governance structure within Germany allows Munich to respond in its own way to growth management and climate change. What works in Munich may be different to what works in Berlin or Stuttgart. Each city has the ability and the authority to experiment and innovate in various forms of infrastructural management.

The second point relates to the nature of Munich's own institutional context that allows for innovative forms of infrastructural governance to emerge. The large number of high-tech multinational companies involved in technological innovations that have headquarters in Munich is significant, in that officials, planners and innovators have access to international knowledge networks that can provide custom-made solutions to complex problems – The involvement of Siemens in the *M-Partnerkraft* project is one example. The specific institutional context of Munich has allowed for the experimentation in governance and technological developments that have emerged over the past few decades. In this chapter I have examined three examples of these innovative infrastructural projects. The first example is the Inzell discussion group, which arose following disputes that are occurring in many cities globally. Yet policymakers within the Munich city region were able to create a discussion group with leading manufacturers and researchers to avoid conflicts over urban planning. The conflicts and bitter disputes surrounding infrastructure financing in the 1990s that led to a number of referenda against the council's wishes were arguably the catalyst for the high-level Inzell discussions and the desire to avoid such confrontations in the future, leading to the integration of various public and private partners within governance networks. When the existing governance structures began to break down in transport discussions and led to confrontation and conflict between the city and major manufacturers, Inzell demonstrated that an innovative model specific to the city region of Munich could be created – regular dialogue was created between public and private operators, early and frank discussions over potential flashpoints were routinely held, and the joint development of urban plans has led to cooperative partnership working between the public and private sectors. Similarly, many cities are struggling with the technological lock-in associated with proprietary software, however the resources and operational freedom available to managers within Munich has allowed for the creation of the second infrastructure project examined in this chapter: the context-specific Limux operating system developed within the local authority. Although the Limux project took more than a decade to complete the city has demonstrated its desire to become independent from often unreliable (and uncontrollable) private sector providers, to use its considerable resources to retain IT spend within the city region and to encourage local SMEs and start-ups to develop software and solutions without the constraints being imposed by the large US technology companies. While the Inzell discussions

can be seen as evidence of the incremental innovation key to German capitalism and the further neo-corporatisation of urban life, the Limux project perhaps demonstrates the ability of determined and single-minded 'system builders' to innovate when given the space and opportunity to do so. The third example of innovative infrastructural governance examined in this chapter is the evolution of SWM from a holistic provider of services focused mainly on Munich residents into a European-wide operator with a continental portfolio of renewable generation assets. New laws at the European level have restricted forms of infrastructure cross-subsidisation – similar to the judicial splintering occurring in Seattle discussed in Chapter 5. However, instead of the SWM retreating into becoming a Munich-only energy utility, it has instead utilised the new laws to create a portfolio of renewable energy projects across Europe, to integrate small decentralised operators into the wider grid through the *M-Partnerkraft*, and to begin selling energy to customers throughout Germany. What was originally a series of laws intended to create competition within the energy sector and to prevent publicly-owned utilities from 'crowding out' private competitors has been innovatively used by the SWM to become one of the largest publicly-owned utilities in Europe. Although the laws do not allow integration in cross-sectoral terms, they have allowed the SWM to increase the level of integration within the energy sector. Arguably, these three projects meet the definition of the concept of infrastructure integration advanced in Chapter 2:

> *The bringing together of technologies, actors or organisational structures (whether through changes in governance, operational practices or forms of service provision) at a variety of scales and forms that can lead to more sustainable, economic and resource-efficient infrastructure networks.*

Using the conceptual framework developed in Chapter 2, what I describe as innovative integration can be graphically represented in Figure 6.3.

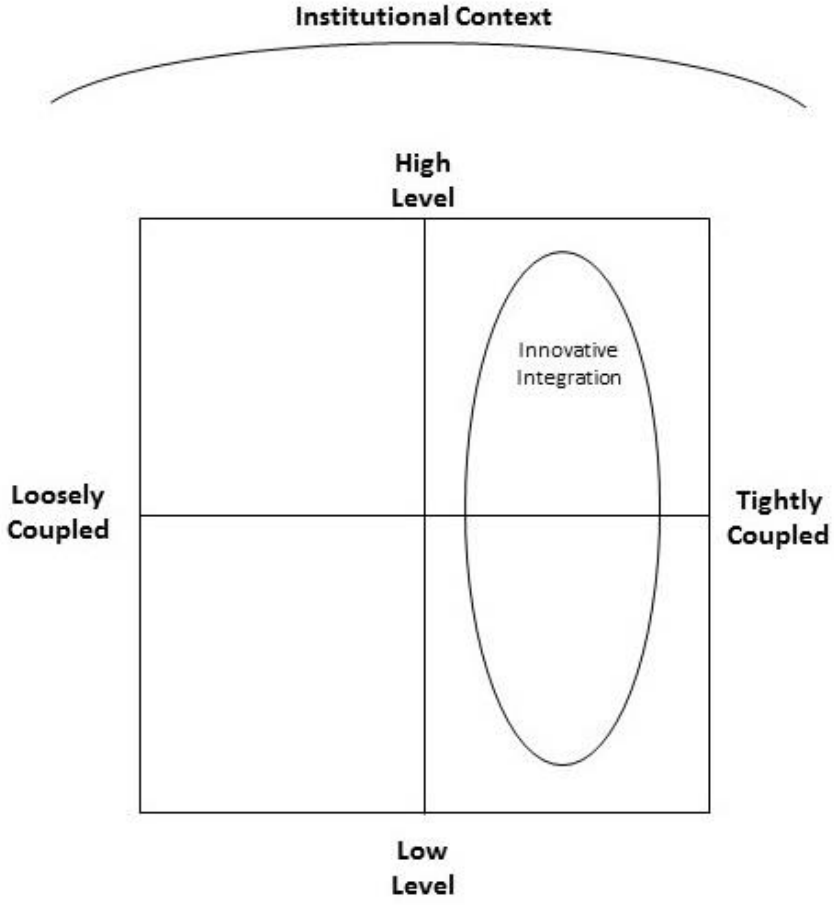


**FIGURE 6-3 MUNICH'S INNOVATIVE INTEGRATION**

The large coverage within the diagram reflects the prominence of infrastructure integration within Munich. The strategic nature of infrastructural discussions within the city leads to integration occurring at a 'high-level' in this terminology – the creation and adoption of the Munich Perspective is a good example of this. However, the widespread support of integration means these strategic goals can be diffused throughout all levels of city governance, hence the inclusion of lower levels of integration within the conceptual framework. The Central Railway Lands project, although low-level in terms of being a single development project, still employed and developed the integration goals outlined at the higher strategic level. In terms of tight vs loose coupling, the collaboration between the public and private partners can lead to decisions being made and policies being advanced through partnership working, leading to a form of 'tight' coupling in infrastructural decision-making. Yet, the decentralised nature of Munich's governance can allow for pockets of small-scale innovations to emerge, such as the Limux project.

# 7 SHEFFIELD: THE ASPIRING STRATEGIC CITY

Sheffield was chosen as a case study for this project as it appears to be a city operating within an institutional environment that may make infrastructure integration difficult. Cities in the UK often have little capacity to intervene and have restricted authority to act over infrastructural concerns. The UK's infrastructural landscape is market-orientated and the major utilities are splintered and siloed from each other (Graham and Marvin 2001). Many utilities are privatised and are managed by national and multinational companies that may not take into account the needs and desires of urban actors. Indeed, there is little direct authority urban actors can have over the actions of companies responsible for managing national infrastructures. Yet, the argument in this chapter is that the City of Sheffield does attempt to direct the infrastructural providers to cooperate on projects by exerting forms of indirect control over the large operators. As a result, Sheffield offers an example of a city that *aspires* to create a form of *strategic infrastructure integration*. However, it is debatable how successful the city is in achieving such control and, unlike in Seattle and Munich, it can find it difficult to exert control over infrastructures.

This chapter begins with an exploration of the institutional context of Sheffield. Then, I examine what the concept of infrastructure integration means to interviewees within the city. The main argument is that many concerns revolve around economic growth and the ability for city authorities to act as tools for the enabling state. After this, the chapter examines the main issues impacting upon infrastructure integration within Sheffield: the neoliberal enabling form of UK statehood; the inability (or unwillingness) for local authorities to directly provide infrastructural services; and the creation of city masterplans to direct investment, alongside attempts to facilitate dialogue and cooperation amongst the splintered infrastructural providers. The chapter ends with a discussion of what I describe as the *aspiring strategic* form of infrastructure integration.

## 7.1 SHEFFIELD'S INSTITUTIONAL FRAMEWORK

Sheffield is a traditional UK industrial city in South Yorkshire. The wider metropolitan area is made up of four local authorities – Sheffield, Doncaster, Barnsley and Rotherham (Figure 7.1) – and is bordered on the west by the Peak District National Park. Sheffield has a population of just over half a million and is the fifth largest city in the UK. Its population is expected to grow by 7 percent by 2025 (Office of National Statistics 2016). Beyond the urban centre the Sheffield City Region is made up of nine local authorities with a population of 1.7 million people. This area contains the coalfields on which Sheffield's large steel industry was developed (Winkler 2007) and for much of its history the city stood as one of the world's major steel production centres – steel was responsible for over 40 per cent of the city's 300,000 workers by the early 1970s (Crouch and Hill 2004). This dependence left Sheffield deeply affected by the widespread restructuring associated with the UK-wide decline in manufacturing in the 1980s (Dabinett 1998). While the traditional manufacturing base was once a key comparative strength of the region there have been shifts over the past few decades from a high-paid, skilled employment economy towards a low-paid, deindustrialised service economy

(Etherington and Jones 2009). To try and counteract the decline of the steel industry the city has pursued investment into a new light rail network, major highway improvements, investments in business parks and city centre regeneration and city authorities have tried to shift the area towards a more knowledge-intensive economy (Williams and Vorley 2014).

The city has two universities – Sheffield University and Sheffield Hallam University. The region has been historically dependant on large public sector employment, which in 2014 accounted for 37.2 percent of the workforce, the majority of which is concentrated within the city centre (Williams and Vorley 2014). Central government spending cuts since 2010 have forced the city to realign its priorities towards promoting entrepreneurship in core sectors such as advanced manufacturing, healthcare, logistics, creative industries and low carbon developments. The city region's unemployment rate was 10.7 per cent in 2014 (The LEP Network 2014).

Institutional relations within Sheffield are tied to the city's development as a major manufacturing centre in the 19th Century, with large working class communities situated alongside the manufacturing areas to the east of the city centre, largely situated in the Lower Don Valley (Raco 1998). The working class politics of the city ensured that the Labour party has dominated politics in the city for much of the last century. Up until the 1980s city policy involved 'benevolent paternalism' (Booth 2005), ensuring the population was housed and educated with access to a good range of services. During the economic decline of the 1980s the city launched a form of 'local socialism' – using public spending to counteract socio-economic problems – to address economic problems with the decline of the steel industry.


**FIGURE 7-1 THE CITY OF SHEFFIELD**

These policies were attempted while the Thatcher government was radically changing the face of local government in the UK (Raco 1998). While Sheffield politicians remained practical in their

response to economic problems, the city's unemployment rate tripled between 1981 and 1984 with the loss of 30,000 manufacturing jobs (Seyd 1990). Sheffield was politically radical in response to the Thatcher government, as were others in UK local government during the period – such as those in Liverpool who demonstrated outright hostility to central government – yet the city authority was seen as "isolated from business interests" and, with the lack of local power, "could neither provide an adequate form of governance for a city's crisis-ridden economy alone, nor easily form alliances with others for the task" (Crouch and Hill 2004: 182). Finance became increasingly controlled by central government and city authorities were severely curtailed in their actions. The economy of Sheffield suffered as the steel industry began shedding jobs and attempts by the weak city authority to step in ultimately failed. The local authority was "ill equipped" for the task and "felt alienation from and hostility to the firms, which seemed to be walking away from the problems" (Crouch and Hill 2004: 181). At the time the city also saw a number of centrally-controlled QUANGOs (Quasi-Autonomous Non-Governmental Organisations) created by the Thatcher government take over control of economic development such as the "Sheffield Training and Enterprise Council (STEC), the Sheffield Development Corporation (SDC), and the Sheffield Health Authorities and a whole host of centrally funded bodies, such as local Grant Maintained schools and Housing Associations" (Raco 1998: 982) altering institutional relations within the city and depriving local authorities of any involvement in employment and skills, welfare provision and economic development. In reality, Sheffield City Council's powers and ability to influence change within the city were 'haemorrhaging away' during the 1980s (Raco 1998).

Policy within Sheffield shifted in the later 1980s and 1990s, away from conflict with central government and private interests towards one of partnership, or to what Crouch and Hall described as from a "local *government* model of regeneration dominated by the city council to a local *governance* model represented by a range of organizations working in close cooperation with all levels of government" (Crouch and Hill 2004: 185). The Lower Don Valley was to be redeveloped under the auspices of an Urban Development Corporation – a planning organisation controlled by centrally-appointed private nominees rather than local planning officers. Further change came when the European Union provided money under its Single Regeneration Budget (SRB) in 1994, requiring a multi-actor partnership between public, private and voluntary bodies. Sheffield received funding in all six competitive bidding rounds of the SRB. Regeneration continued through the 2000s with an emphasis on partnership working with the private sector. The New Labour government created a Sheffield Urban Regeneration Company (URC) in 2000 under their direction of 'joined-up' government to bring together various partners in the economic development of the city. Since the election of the national Coalition government in 2010 economic development within the city is being increasingly private sector-led, with powers being devolved to city regions from central government. This has continued since the election of Conservative governments in 2015 and 2017.

In terms of regional cooperation, the Sheffield City Region (SCR) was created under the New Labour government in 2004 and encompasses the metropolitan county of South Yorkshire, the four districts from north Derbyshire and one district from northern Nottinghamshire. When it was first created the SCR crossed the territories of two Regional Development Agencies (Yorkshire Forward and East Midlands) as well as two Sub Regional Partnerships (South Yorkshire Partnership and Alliance Sub Regional Strategic Partnership) complicating the discussions around strategic development and economic growth. Since then the region has been given further devolution on a piecemeal basis. The SCR Local Enterprise Partnership was one of the first of its kind in the country and was created in

2010. The regional LEP is designed to be private sector-led with the aim to promote local economic growth. Under this there is a Sheffield City Region Infrastructure Fund (SCRIF) which has helped fund the Olympic Legacy Park, the Peak Resort leisure destination, improvements to the M1 motorway and essential transport and broadband improvements. The SCR was also the first in the country to submit plans for a Combined Authority, which was created in April 2014 (Treasury 2015) and is designed to provide the powers and funding to underpin the more development-focused LEP. While the UK remains a highly centralised nation ("central government utterly mistrusts local government, and on occasion we give them good reason to" interview, Sheffield consultant) as part of the devolution deal the city region will gain further powers over transport, strategic planning, employment and skills, as well as funding from central government that is not ring-fenced.

Similar to other UK cities infrastructural management within Sheffield is often splintered and managed by national private utilities. Governance of the city's networks is summarised in Table 8.1. Telecommunications and energy are largely served by the national private utilities, however Sheffield has the UK's largest and most successful district heating network, although the technology is not widespread across the UK. The network provides electricity generation and community heating and is operated by private operator Veolia in conjunction with Sheffield City Council. It provides services to 140 city buildings including shops, hospitals, hotels and the majority of both universities (Finney et al. 2012). The city region did attempt to create its own arms-length broadband network (see section 7.3.2) however the scheme has since been cancelled. Water and sewage is managed by the private monopoly Yorkshire Water.

There is also a city centre tram service. The route was chosen to prioritise economic regeneration efforts in the east and north of the city and received £233 million in support from central government – a further £7 million came from private funding, most from the developers of the eastern Meadowhall Shopping Centre. However, researchers claim the tram failed to generate the numbers of passengers it originally claimed, and in 1997 the network was sold to a private bus company for £1 million to cut operating losses (Winkler 2007).

| | Water Sewage Drainage | Heating | Energy | Waste | Transport | Telecommunications |
|---|---|---|---|---|---|---|
| **Main Actors** | Yorkshire Water | Extensive district heating network managed by Veolia | Sheffield Energy Recovery Facility (managed by Veolia) | Contracted to Veolia | Deregulated market competition in public transport | Market competition dominated by large national providers (BT, Sky and Virgin) |
| **Comments** | Private utility operating under regulated monopoly. | Provides services to 140 city buildings including shops, hospitals, hotels and the majority of both universities | The ERF also provides heat for the district heating network. | Formal contracting between Veolia and local council. To optimise material recovery and meet environmental targets (Watson and Lane 2011) | New transport powers expected to be given to Sheffield City Region as part of devolution deal | Attempt to create publically-owned broadband network to serve the areas bypassed by the private companies failed in 2013. |
| **Other Actors** | | Smaller second district heating network operated by E.ON. | National market competition | | City centre tram network, operated by private company Stagecoach. | |
| **Principles** | • Infrastructure provision dominated by private utilities operating under open market competition.<br>• Local authorities relegated to a coordinating and strategic role. Lack of capacity, funds and power to fill infrastructural gaps directly<br>• New transport powers being offered to the city region under devolution deals. Funding may be released without ring-fencing restrictions. | | | | | |

**TABLE 7-1 THE MANAGEMENT OF SHEFFIELD'S INFRASTRUCTURES**

## 7.2 Interviewee Perceptions of Infrastructure Integration

When respondents in the Sheffield City Region were asked what they thought the concept of infrastructure integration entails, many spoke in economic terms, of the importance of creating private sector-led economic growth and allocating the spatial spread of new jobs, homes and infrastructure networks across the city region. What became apparent during the interview process is that, unlike in both Seattle and Munich, discussion quickly moved away from a focus on the direct provision of infrastructural services. The splintered nature of UK infrastructural markets and the neoliberal state's traditional role as an incentivising and enabling state rather than a direct provider of servicers (see Chapter 4) may make it difficult for a city such as Sheffield to influence many of the private national utility providers. Unlike in Seattle and in Munich, there is no department within Sheffield City Council that has the ability or will to directly govern the city's energy, water or telecommunication networks. Instead the majority are owned and managed by large private utility companies: Yorkshire Water covering the regional water supply; BT, Sky and Virgin covering the telecommunication networks; and the competitive national energy market which offers little scope for city officials to intervene. While the city of Sheffield does own the award-winning district energy network, the day-to-day governance is contracted out to the environmental services company Veolia, which has a 21-year contract. When asked if there were discussions about the city creating its own publicly-operated energy network (or bringing management of the district heating network in-house) one official said:

> "I don't think it's out of the question in terms of what our ambitions are. If we found that running our own energy company means we have a more resilient supply that we could possibly deliver cheaper to key providers, then it's something we'd think about, because the business community tell us that energy prices and energy resilience is one of their big issues in terms of **economic confidence**. So if that becomes an issue to us, then we would be prepared to do that" (interview, Sheffield City Council executive, emphasis added).

Economic confidence appears to be the primary motivator for interviewees in terms of infrastructural provision. What the above quote suggests is there is no appetite for the city authority to become involved in the direct provision of infrastructural services. While Sheffield theoretically *could* create its own energy network, it is highly unlikely. Part of this is the regional experience in attempts to create a new broadband network (see below). However, respondents also appear to differ on what the definition of the word "infrastructure" actually entails and what it is that a city authority should focus on. While energy, water, waste and telecommunications networks are clearly important to planners and city officials, the emphasis for city planners is focused more on housing, jobs, schools and creating the environment for economic growth: or, in other words, fields in which the local authority has a degree of control. While the respondent above spoke about creating a publicly-owned energy utility only if it would provide economic growth, another summed up the general thinking amongst respondents.

> "I guess for integration we are kind of less along the lines of delivering that infrastructure altogether, to one of that approach in terms of shared outcomes and trying to define through the integrated infrastructure plan **what the barriers to economic growth are**, what are the key pieces of infrastructure, or gaps in our infrastructure, that are holding us back, and therefore

where we should prioritise investment (interview, Sheffield City Council executive, emphasis added).

Another interviewee, when asked to define infrastructure integration, said:

> "I think its planning, and if possible, delivery. And I suppose when I say infrastructure I mean economic infrastructure" (interview, Sheffield City Region official).

Another added:

> "So the scale of economic growth, where it's going to be located, what does that mean for housing and infrastructure? That's quite an integrated approach, that type of work is happening at the city region level, collaboratively between the local authorities" (interview, Sheffield City Council Planner).

The role of the local state to focus on international competitiveness is also apparent:

> "We've got long term ambitions to make Sheffield one of the most sustainable cities from an energy point of view, so therefore [it's about] creating the long-term confidence for them [private utilities] to say 'yeah we can invest, the city is committed to that, so we can come in and invest, we want to be part of that solution'" (interview, Sheffield City Council planner).

The splintered nature of the UK infrastructural networks (Graham and Marvin 2001) restricts what local authorities in the UK can and cannot do in terms of infrastructural provision. As outlined in Chapter 4, the UK is a highly-centralised state and historically city authorities have been reliant on national government for funding and the granting of powers. While both Seattle and Munich have publicly-owned utilities with a modicum of social equity and universal provision, cities in the UK are constrained by many infrastructures being governed by other actors, often privatised and often large multi-national companies. City authorities lack the funding and the ability to directly influence private utilities. One interviewee discussed the reality of attempts to integrate infrastructures within the UK:

> "…one [form of integration] is in the delivery of it, and in a way, under the current governance it would never be integrated anyway. Because BT is a private PLC. Yorkshire Water is as well, we are a local authority, we have all got different objectives, micro objectives, we all have the overall objective of making the city bigger, better, greater, a more pleasant place. But our individual day-to-day objectives and laying cable or pipes are very selfish still" (interview, Sheffield City Council planner).

One interviewee gave an example of the difficulties in attempts by local authorities to navigate the myriad ownership models of different infrastructures:

> "At the moment we have the tram extension from the cathedral to Rotherham. And that needs new infrastructure on the heavy rail network which Network Rail is responsible for, some of that requires amendments to bridge heights to accommodate the overhead wires, which aren't there at the moment, and that affects our network, and even when it's a scheme they are promoting they are not the best at communicating back requirements and providing information, so there is

an issue there in terms of that partnership coordination approach" (interview, Rotherham transport official).

Difficulties also arise in local authority negotiations with different organisations within the same sector, such as telecommunications, suggesting the varying cultures of external organisations can be just as important as the powers offered to local authorities in dealing with utilities:

"The worst one is BT (British Telecom). That's just…. it's just desperate. They've got a different agenda really, and they are the most siloed of everybody, and they are more siloed than their competitors are, so the likes of Virgin, we have no issue with them, they always come to our meetings, they are always up front about what they are planning to do, and they look for help and for working with people, but BT, no" (interview, Sheffield City Council transport official).

These quotes summarise the definition of integration that arose during the Sheffield interviews. Many respondents saw infrastructure integration in terms of urban planning: examining where housing and infrastructure should be built and where future growth zones should be, rather than in the direct provision of services by the local authority. In order to deliver this economic growth, and to plan where the growth zones should be, infrastructure integration involves top-level information sharing between organisations and in the creation of masterplans detailing where infrastructures should go. While there is a role for the local authority in infrastructural provision this is relegated to acting as a pivot around which other organisations can align their own investments. The sectoral and functionally-focused nature of UK infrastructures is not necessarily conducive to actual integration: instead the city authority attempts to create an *alignment* of information between organisations and acts as a *coordinating* authority for joint projects. Key examples from interviewees include:

"My take on integration is that you bring together the different types of infrastructure needed to make the city work… its planning, where it's going to be" (interview, Sheffield City Council Planner).

"It means joined up thinking to me. Integration is one thing, in practical terms it's about bringing multiple services together under one umbrella, it would be utopia but I'm not quite sure that that's realistic. But I think if there is a conduit to facilitate joined up thinking in terms of planning, for example, so if we were digging up the road to lay pipe work for a new section of our energy into the city, you'd make sure that that would be coordinated with road works being developed or British Gas or the electricity board wanting to put pipe works in as well. I think that's what's probably missing in terms of 'integrated', more like joined up thinking" (interview, Veolia executive).

"I think the key role of local authorities is to set out where that long-term growth is going to go and the infrastructure needed to support that growth" (interview, Sheffield City Council Planner).

While the splintered infrastructural networks make it difficult for Sheffield City Council to exert influence over the privatised utilities, it does have advantages in terms of efficiency and in creating nimble and adaptive technological networks. Veolia, which manages the district heating network and operates waste management services, is a large French multinational company with 318,000 employees in 48 countries. The ability for the company to share knowledge across borders was highlighted as a key advantage to Sheffield's operations by one official:

> "It can be very insular in a city, despite what people say in terms of learning from other core cities in the UK. We [Veolia] can go to core cities in Europe or America and we have a district heating network in Poland, in one city its 10 times what we do in Sheffield, if not more, so we can learn from that technology, how to improve it. Sheffield City Council if they were doing that themselves, would find that very difficult" (interview, Veolia official).

Instead of directly offering infrastructural services the city should instead be a facilitator that mediates between organisations with different objectives. One interviewee said:

> "I think we see ourselves very much as an enabler. We are working with E.ON at the moment who want to roll out district heating. We're sort of bringing them together with local businesses… so that's an enabling role. But the local authority itself can start getting directly involved. We own social housing estates and we can start to become a customer that makes their business model viable, so we can work in different ways from just an enabling form to actually taking a direct commercial interest in what's being provided as well" (interview, Sheffield City Council planner).

Many respondents saw the role of the local state to act as this enabling and incentivising organisation to coordinate investments and to act as a conduit for commercial organisations to work under. One interviewee said:

> "…if I'm being honest, that's why you have a public sector, that's why the tax payers support the local authority executive, because they should be doing things like that and they should be able to overrule stupid short-term decisions for the overall good" (interview Sheffield Chamber of Commerce official).

However, while the city authority should in theory act as a strong central pivot to bring varying organisations together, the existing capacity for Sheffield City Council to act in this way is questioned by a number of interviewees. There is a disconnect between the perceptions of integration from interviewees within the public sector (with the belief that the city should and does play an enabling role and act as a lead organisation in infrastructural discussions) and the perceptions of interviewees from external bodies, who felt the rhetoric from public leaders was not often met in reality. There is a difference between the theoretical vision of integration and the problematic actually existing forms of integration in practice:

> "People say integrated infrastructure would be really good, and we all say 'yeah', but now what do we mean. So what do we mean in theory? I guess it's more how it's developed together, and then there's what does it mean in practice, in terms of how things are delivered together. And you often get anecdotal examples of the water company saying if only they had known the highways company were digging up the road we could have saved this, in funding terms, but actually those things still never happen. (interview, Sheffield City Region official).

When asked if Sheffield City Council acted as an effective coordinating body in practice a respondent from Veolia said:

> "It's not particularly joined up in that way. In theory it should work that way, but in practice it doesn't work that way. I think you always have to have an organisation to be able to coordinate and understand all the different elements. Unless you return these infrastructure companies back into public bodies – therefore in theory they used to be more joined up, because it was one sort

of state-owned organisation – unless you do that you still need a conduit to coordinate and bring it together, and there's only one organisation that can be, and that has to be the city council" (interview, Veolia executive).

Another interviewee, when questioned about problems in partnership working with neighbouring authorities, said:

"I think the biggest thing for me is information asymmetry. And it's nobody's job really to join it all together, so everybody just carries on. And nobody thinks to ask the question 'should it be coordinated?' And the question is so difficult and public sectors have been cut and all the rest of it, but it just never really comes up. If it comes up it seems to come up by chance rather than design" (interview, Sheffield City Region official).

Despite many interviewees viewing Sheffield as a strategic leader, one interviewee said there was no one within the authority working on integration in strategic terms. When asked if there were any officials tasked with improving forms of institutional integration, the respondent said:

"Not strategically. I imagine it depends as much on the abilities of the individual project managers, who could probably ask the right questions around utilities, and if a broadband scheme is coming up here, and what else can I get in. I don't think it comes strategically. It's not a top down… 'ok for anybody working on this you have to check x y and z before', I don't think it comes that way, is my experience" (interview, Sheffield City Region official).

## 7.3 Issues Impacting Upon Infrastructure Integration

While Sheffield City Council may have a desire to provide strategic forms of integration, it appears to be a problematic concept that does not actually happen in practice. There are four examples that encapsulate the issues inherent within the institutional environment within Sheffield that impact upon infrastructural integration. First, the Streets Ahead project offers an insight into the positive ways local authorities can act as lead organisations in delivering projects. The project is one of the largest Private Finance Initiative (PFI) schemes in the UK and will see the city's entire road network replaced and upgraded. The project is an example of the local state acting as an enabler for the private sector. Second, the South Yorkshire Digital Broadband scheme highlights the problems associated with local authorities attempting to provide services directly in competition with the private sector. The scheme has largely been seen to be a failure and is in the process of being wound down. Third, the creation of city masterplans within the centre of Sheffield offers an insight into the local authority's role as a coordinating authority, being in a position to bring disparate organisations together and mediate between them, focusing on alignment over direct integration. However, the problems associated with a council lacking in power over the activities of private utilities can restrict the effectiveness of these long-term city plans. Fourth, is the attempt to create a region-wide combined authority to receive funding and powers from central government under staged devolution deals. The deals have been delayed due to a number of local authorities pulling out over concerns over consultation, 'land grabs' and preferences towards a wider 'One Yorkshire' authority. I will examine each of these issues in turn.

### 7.3.1 THE STREETS AHEAD PROJECT

The Streets Ahead programme is one of the biggest PFI highway maintenance schemes in the UK. The 25-year, £2 billion contract will see most of the city's roads, pavements and streetlights replaced between 2012 and 2017, with contractor AMEY then responsible for maintenance until 2037. The contract offers an example of how Sheffield City Council can act as a lead, coordinating authority by pressurising private utilities to share their plans and realign their investment portfolios to avoid further disruption to citizens. The alignment of investment projects by the disparate utilities has been key to the contract's success. As one interviewee said:

> "We've been working very closely with all of those companies over the last few years to say 'look, we've got this big project coming up, can you rearrange your programme of investment so that you go into our roads and our pavements before we do, so then what we are left with is a smooth pavement that you don't go and dig through?' We've got a lot of that going on" (interview, Sheffield Highways official)

The contract offers an incentive for utilities to install their own pipes and cables at the same time as the road maintenance work, by allowing them access without the high costs associated with repaving the street. It also places pressure on the utilities by refusing them access for the next five years:

> "The infrastructure providers see an opportunity where they can go into the road network and change things, they've started aligning their investments, because the rule of the PFI is we are going in there, we are doing these street works, and then once we have gone in, you can't touch it for five years. So they have all started thinking, 'hang on, we better align our investments here, because we don't want to be caught out and not be able to go in'. So what we've seen in Sheffield is a real step up in the activities of the major utility providers to try and coordinate their investments with when Streets Ahead is going through the city" (interview, Sheffield City Council Planner).

As part of this investment realignment the city council has created a team of officers within the highways department to coordinate the projects of the various utilities operating within Sheffield. This small team has access to the future investment plans of the major utilities. While the aim was to have a single point of interaction between the city council and external organisations, it has also created a single point of contact for other teams within the city itself. One official said it was a way to "gently bang heads together" (interview, Sheffield Highways official). Another interviewee said:

> "In some parts of the city you might have 10 or 15 different infrastructure providers wanting to do stuff, so we can't just allow them all to do it in isolation. We have a team that says 'OK so you want to do this, you need a permit for it, you want to do that, I'm aware of that, and we will coordinate it all for you', so you minimise the impact on traffic and movement in the city, and make sure that we are not, in crude terms, digging a hole three times when we don't need to. We do try to have a coordination role at the micro level, but we also advise the city at a strategic level to be clear on what our plans are and have strategic relationships with the key providers as well" (interview, Sheffield City Council Planner).

However, there are unintended consequences with this:

> "[There is] something in the [Streets Ahead] contract that says 'if you come and dig our road up within the five years that it's been done, you are responsible for putting it back'. Now that's understandable from the quality point of view, but it is a pretty big disincentive to BT and Virgin. We are encouraging BT and Virgin with one hand to up their coverage of next generation broadband, and on the other hand we are making it more expensive to do it in Sheffield than in other places. So it's an unintended consequence. They're saying in Rotherham 'I can just lay my little bit of pipe and bugger off, in Sheffield I've got to lay my bit of pipe, and then I'm responsible for the rest of the road surface. Well I'm not going to do it then'. And then we've got businesses saying 'why haven't I got broadband'. So there are unintended consequences in all of this" (interview, Sheffield consultant).

A further problem with the Streets Ahead contract is the removal of local authority control over discretionary transport spending and the contract lock-in that will restrict the council's flexibility over the next 25 years. The contract will see the removal of the £6 million of central government's Local Transport Plan Maintenance Grant, to be replaced with PFI funding to cover the length of the contract. The impact of this will be to:

> "…create greater budgetary discipline than before in that the future maintenance costs of changes to the network have to be identified at the point of construction. This is done by calculating the future costs as a "commuted sum" which is usually funded out of the existing revenue budget. As the austerity programme reduces local authority budgets, there may come a point where new works are unable to progress because the Council cannot meet the future maintenance obligations" (Sheffield City Council 2016: 431).

### 7.3.2 South Yorkshire Digital Region

The second project I wish to highlight is the South Yorkshire Digital Region (DRL) scheme to roll out high-speed broadband across the region. The Digital Region scheme was created in 2008 by the four South Yorkshire Councils – Sheffield, Doncaster, Barnsley and Rotherham – and the regional development agency Yorkshire Forward. Sheffield City Council invested £14m into the project, with Barnsley, Doncaster and Rotherham investing £7m. A further £30m came from the European Regional Development Fund. The creation of a Special Purpose Vehicle (with the five organisations as shareholders and guarantors) was designed to create a high-speed broadband network operated by an arms-length provider, as it was felt the national broadband utilities (such as BT and Virgin) were not investing in the region. One aim was to stimulate economic growth in the area. In 2013 it was announced the project would begin managed closure as the "project costs to achieve financial stability, and the barriers to enable the project to proceed in a sustainable manner, were prohibitive" (KPMG 2014: 3).

One problem was the length of initial discussions to get the project started and the bureaucracy associated with having several public-sector organisations involved and no clear lead organisation. Discussions to create the DRL began between the four local authorities in 2005, and between then

and its eventually wind down in 2013 the telecommunications market in South Yorkshire had "changed enormously" (KPMG 2014: 4).

Further problems include the confusion sown by the involvement of five councils in board meetings – there were no technical specialists involved in at the board level and no one was able to challenge the technological aspects of the projects; a poor sales and marketing plan that was not drafted until the DRL was created; and optimistic customer sign-up projections – the initial aim was for 100,000 customers. While the scheme had managed to make superfast broadband available to 80 per cent of the region, at the time of its wind down DRL had just 3,000 customers (KPMG 2014, Newton 2014). The cost of the project when it ended was £83.3m.

One further problem was that the DRL project may have caused the national telecommunication providers to delay or cancel their own investment plans in the region. Nationally, BT Openreach had plans to upgrade its street cabinet infrastructure to provide 40 per cent of homes with superfast broadband by 2012. However, the plans did not include Sheffield, which according to a consultant report on the region's infrastructure, "may be linked to the fact that BT are aware of the proposals by Digital Region to undertake a similar investment programme" (WYG Engineering 2010b: 28). While the lack of investment in Sheffield may be due to the DRL project it could also be to an adversarial culture within BT itself, as the company was not willing to contribute to a "Sheffield Energy and Water Infrastructure Study due to perceived concerns over the confidentially of their planned capital investment programme"(WYG Engineering 2010b: 28).

In 2013 Michael Fallon, the Minister of State, Department for Business, Innovation and Skills, summarised the problems with the DRL scheme when he told a parliamentary committee:

> "DRL's purpose was to provide high-speed broadband in a disadvantaged area to support growth and job creation. However laudable the motive, the project was deeply flawed. A combination of delays in appointing a contractor to build and run the network, failing to adjust as necessary in a fast-moving business sector and insufficient—in fact, zero—income risk being allocated to the network operator made the business hopelessly uncompetitive. I could go into how Yorkshire Forward should have been more agile and responsive as business conditions changed radically in the south Yorkshire broadband market while the DRL network was being commissioned, but doing so would sadly serve no purpose now.
>
> "My Department inherited a difficult situation from [the Regional Development Agency] Yorkshire Forward, because we were faced with a technically advanced broadband network that was financially unsustainable. Contractual arrangements allocated all financial risk to the shareholders, providing no incentive at all for the operator to compete with the market leaders that entered the south Yorkshire broadband market. Simply to close the network was expensive, because severance costs had to be paid to existing contractors and the European regional development fund grant of £27 million that part-funded the construction had to be repaid."

He added:

> "The Government, guided by the Industrial Development Advisory Board, do not believe it appropriate to play a long-term and, in view of the 50% shareholding we inherited, decisive part in this regional asset, nor to provide from additional taxpayers' money support that in the long

run cannot be sustainable… The contract was very poor and extremely badly negotiated. It has not been managed successfully, and the marketplace has moved on" (Financial Assistance to Industry 2013: col 3 - 10).

### 7.3.3 City Centre Masterplans

Since 1994 Sheffield City Council has created a series of masterplans to outline the future development of the city and to identify where future growth zones should lie. A series of masterplans were published in 1994, 2000, and 2008, with the latest "Sheffield Plan" – setting out how and where development will take place up to 2034 – due to be published in 2018. The 2008 city centre masterplan was intended to "provide the physical development and delivery framework to achieve the economic transformation of Sheffield in accordance with strategic policy objectives" (SCC 2008). A review on the masterplan process adds:

> "The focus of the Masterplan Review is therefore on economic growth. It takes its lead from the city wide Economic Masterplan and sets out comprehensive proposals for further investment in high quality development, public realm and infrastructure and identifies the key projects which together will make Sheffield a more attractive, successful and competitive city centre. As with the 2000 Masterplan, it aims to give clarity, direction and confidence to partners in the private and public sectors. Achievement of this shared vision will be dependent on effective partnership working to ensure a bright and prosperous future for the city and to create a city centre that competes with the best in Europe" (SCC 2008: 3).

Not only does the masterplan intend to promote partnership working but it also aims to provide stability and long-term direction for other organisations to align their investments with. Information sharing between organisations is seen to be key and the alignment of various projects could help reduce the 'siloing' of utilities ("how do you mitigate against those silos, and that's by talking about, informing people as far in advance as you possibly can do of any plans" interview, Sheffield City Council transport official). However, while the aim of the masterplan is to offer Sheffield City Council up as a visionary lead authority – as one interviewee said, just who else could act in that role? (interview, Sheffield Chamber of Commerce official) – the lack of powers available to Sheffield to force other organisations to follow its lead causes a number of issues.

First, the masterplan is 'market-led' and provides guidance on where growth should be directed. It does not act as a vehicle for the city authority to offer direct provision of the services or infrastructures needed to provide that growth. In the UK it is often left to developers to fund the necessary infrastructural improvements needed to service developments. Also, the city authority can often be reliant on private utilities to upgrade their infrastructures according to their own timescales. While city authorities can attempt to put pressure on the private utilities, they have no mechanism to force utilities to change their own investment priorities. One example is the investment programme initiated by YEDL (the regulated Distribution Network Operator for Sheffield and part of the CE Electric Group). While YEDL had significant investment proposed for the city areas identified in the masterplan, the city council was very much reliant on these external projects going

ahead before any other private-led development could take place. One consultant report on the issue said:

> "YEDL has committed capital investment either in 2010-2015 (DPCR5) or 2015-2020 (DPCR6) that will in-part mitigate the need for significant developer contributions; to benefit from these planned capital investment works the delivery timeline for a number of City Centre sites must be carefully considered – as the programme of City Centre development will be market led then alternate methods of funding infrastructure in order to remove constraints upon development may be required. Those sites that will trigger abnormal investment need if developed before 2011, 2016 and 2017 are highlighted in this report. Should these highlighted sites be developed before YEDL undertake their planned capital works the developer-led investment need will be approximately £3m-£4.5m per Primary Substation upgrade (not including land). In theory any developer investment will be equitably apportioned across all sites benefitting but this 'apportionment' of capital only operates for 5-years from each investment" (WYG Engineering 2010a).

While the city authority may seek to act as a lead organisation, in some cases it is actually a reluctant secondary following organisation, subservient to the wishes of private utilities which have their own priorities, usually involving a focus on "regulated operational and customer service targets (pressure, leakage, sewer-flooding, security of supply and customer responsiveness) and the need to deliver shareholder value" (WYG Engineering 2010b: 4). As a result, the infrastructural improvements required for economic development within the city are often developer funded, reducing the profitability of some schemes.

A second and related issue is the different timescales that organisations can work towards. For example, while Yorkshire Water has invested in upgrading its facilities in Sheffield, there can be a lag between the priorities identified by Sheffield City Council and the projects developed by Yorkshire Water. Yorkshire Water did set aside cash to upgrade a number of city centre assets during the 2010 to 2015 period, however the utility's investment portfolio was based on sites identified by the local authority in December 2008 (WYG Engineering 2010b). As the utility operates a five-year portfolio for investment, it can effectively delay any developments which would cause it to deviate from its investment plan. Yorkshire Water effectively closed off the redevelopment of several former industrial sites (such as the Stocksbridge Steelworks, Trailer Park and Eastern End) as further housing growth would require "further investment for which, currently, there is no provision" within the 2010 to 2015 period (WYG Engineering 2010b: 11). While the city can mandate a 'sewage undertaker' to upgrade its treatment facilities, the process can only begin once suitable sites are selected under the masterplan – a process that requires widespread public consultation and can take years to complete. One report on the development of city's masterplan highlights the problem:

> "The capital costs associated with upgrading Sewage Treatment Works will not likely be fundable through normal developer led activities without additional public-sector investment and therefore development could be effectively frozen until Yorkshire Water Services are able to programme these works within their regulated business planning activities…The most important activity is for Sheffield City Council Forward Planning to maintain a dialogue with each of the incumbent utility undertakers to share demand forecasting data, spatial planning data (including sites for new infrastructure) and to explore multi-stakeholder value engineering opportunities

including joint forward investment initiatives within or outside current regulated frameworks – the latter might be considered an economic development activity and might be undertaken via Creative Sheffield or Yorkshire Forward" (WYG Engineering 2010a: 23).

The report added:

"Given the strategic importance of utility provision it is perhaps surprising that the only utility undertaker that is statutorily bound into the planning consultation process is the licensed sewerage undertaker. Although this is slowly changing with public access to water undertakers' twenty-five year Water Resources Plans and occasionally Water Cycle Studies there is still a significant disparity between established spatial and economic planning periods and the regulated 5-year capital investment programmes in which the utility companies are expected to operate" (WYG Engineering 2010b: 3).

One interviewee commented on the difficulty in getting private, external utilities to share their own future investment plans.

"I think it's about different organisations having the right mind-sets to see the value of working together in integration. I think it's a communication issue, organisations seeing the value of sharing their plans. An infrastructure provider could say 'no I'm not going to share that because its commercially confidential', but wouldn't they want to see what the bigger picture is and where all the other types of infrastructure are going to be?" (interview, Sheffield City Council planner).

Another identified the different timescales various organisations are working towards:

"Yorkshire Water's investment programme might be aligned to their financial year, which might end in March. Northern Power Grid might have theirs aligned to a financial year that ends in July, the council ends in April, and its makes its decisions in the September before. It's almost impossible to align those things up without solid long term planning" (interview, Sheffield City Council transport official).

A third issue regards the organisational responsibility to resolve disputes between utilities and developers. While several interviewees said the city council should, in theory, act as a mediator in resolving disputes and as an enabler to bring various organisations together, one interviewee offered an example of how the lack of a strong central leader could impact city development:

"Sometimes I despair, a recent example being the big Chinese development at the bottom of Bramall Lane, where there was a big power cable, a multi core cable in there and the utility company wanted to charge an absolutely enormous amount of money to move it, which resulted in them changing the design of the actual building because it was cheaper. And you sometimes wonder, from a taxpayers' point of view, somebody should be able to sit there and say 'come off it, there's a bigger benefit here, this is the bigger picture, we are going to mediate between those two decisions'. There is no sign of that going on. It was just, leave it to get on with it, and planning will do its bit, and utilities will do their bit, and the poor old guy left in the middle trying to bring all this funding in and build this place is just subject to trying to deal with them all as individual things. I have to say I do think they try to some extent, but I'm not sure we always achieve what we should be achieving" (interview, Chamber of Commerce official).

Many of the problems identified within these three examples of integration relate to the amount of power and authority a city such as Sheffield has. One problem is the way local authorities are funded within the UK and the restrictions on grants received from central government. Despite recent moves towards devolution central government retains significant levels of control over local authority funds. In some areas the funds are 'splintered' at the national level and when the money filters down to the local level there is little discretion for city officials. One interviewee, when speaking about transport funding, said:

> "[The lack of integration] is almost a symptom of the way money comes to us, so we tend to plan in silos because that's how the money comes to us. We have to respond to where the opportunity is. At some point in time the Department for Transport has to demonstrate to the Treasury what they have spent their money on, how it is value for money and how it is spent properly. So the need for evidencing the public money was spent on the right things, results in that kind of silo approach, so in order to have rigour and clarity and transparency, you need to put some rules in to show that you did the right thing" (interview, Sheffield City Council transport officer).

Another interviewee said:

> "A general lack of significant investment, not just in Sheffield but across the whole area, has meant we need to get what we can, and if that means that things don't happen in a coordinated way then we haven't got a choice, we either do that or we do nothing" (interview, Sheffield City Council transport officer).

### 7.3.4 The Combined Authority

The fourth example that offers a glimpse into the difficulties in promoting infrastructure integration within Sheffield is the creation and development of the Sheffield City Region Combined Authority (SCRCA). As part of a devolution deal agreed in 2015 the city region is due to gain devolved powers over transport, strategic planning, employment and skills, as well as £900m in funding from central government that is not ring-fenced (over a 30-year period). However, there have been a number of difficulties since 2015 that has meant the full devolution deal has not yet been delivered. In 2016 Nottinghamshire and Derbyshire county councils criticised the agreement as a 'land grab' by Sheffield, while Bassetlaw and Chesterfield withdrew from the deal in early 2017 (Perraudin 2017). In September 2017, Barnsley and Doncaster councils also pulled out in favour of plans for a separate devolution deal to cover the whole of Yorkshire and, to date, the Sheffield devolution deal signed in 2015 has not yet been fully implemented. A mayoral election is still scheduled for Sheffield and Rotherham in May 2018, however the new mayor will only receive limited powers in relation to transport, instead of the wide-ranging powers promised under the original agreement. One respondent within Sheffield criticised the lack of funding offered in the devolution deal:

> "There's far less capacity. It's trying to do RDAs [Regional Development Agencies] on the cheap, without their power and their money. We always say the Combined Authority was always meant to be about taking powers down from national, rather than up from local. The extent to which

that is really happening, is I think probably a little bit unclear. At the moment the Combined Authority is nine local authorities coming to the table together, so it hasn't got that real figurehead and drive which is what government wants, which is why government wants metropolitan mayors, to provide that single figurehead that could take those big decisions that cross administrative boundaries" (interview, Sheffield consultant).

Another interviewee said the Local Enterprise Partnership – which acts as a private sector-led development agency under the SCRCA's remit – represented a change from previous forms of regional governance:

"They (the LEP) are not just a private sector talking shop, they've got genuine… they've got real strong responsibilities, but they can't deliver them in isolation of the Combined Authority, so it's about them working together" (interview Sheffield City Council planner).

However, another interviewee said that there is little engagement from the utilities within the new devolution model, making it difficult for the combined authority and the LEP to take decisions on infrastructural matters:

"I think water come along, they send a representative, but I'm pretty certain we don't have any energy representation. Or even communications infrastructure, I don't think we do. Its predominantly… the attendees are effectively local authority-led. It's pretty much public sector" (interview, Sheffield transport officer).

While this may be resolved in the near future, the lack of any infrastructure representatives on the LEP perhaps gives an indication of the lack of control the newly devolved authorities will have over infrastructural concerns in the years to come. While a £900m investment for the city region is welcome (albeit spread over 30 years) the devolution of powers offered by central government only cover transport, planning, employment and skills – and so far, the lack of agreement over the deal means an elected mayor will be restricted to transport. There is no suggestion that the Sheffield City Region will gain any powers over other infrastructural sectors, and it is difficult to imagine the city creating an organisation similar to the German *Statdwerke* to operate and manage infrastructures on behalf of the city region. The current splintered and national nature of the UK market makes it difficult to imagine the SCRCA being able to promote any meaningful forms of infrastructure integration.

## 7.4 Discussion: Introducing Strategic Integration

Sheffield offers an interesting case study to examine forms of infrastructure integration because UK infrastructures are largely 'splintered' and many cities find it difficult to become directly involved in infrastructural management (Graham and Marvin 2001). This institutional framework structures and restricts the forms of infrastructure integration that can take place within the city. Within Sheffield, infrastructure integration appears to be formed around a discourse of what I term is *strategic*

integration, with a focus on an alignment of project planning and information sharing between organisations with the city authority acting as a coordinating body: a visionary lead organisation that creates masterplans for the region, that can set overall strategies that other organisations can work towards, and as a body that can bring private and public partners together to synchronise project work and pool resources. The strategic city does not have to offer direct provision of infrastructural services, as is the case within Seattle and Munich. Instead the city authority should be attempting to bring providers together to offer services in a "more coherent, joined up and efficient way" (interview, Sheffield consultant). One interviewee described the concept of the strategic city:

> "I think our role as local authorities is to look at the big picture, to look at the long term. By doing that we can maybe start to identify some of the more strategic solutions, that individual utility providers, or individual developers, can't do really" (interview, Sheffield City Council planner).

There are two main issues to draw in relation to Sheffield acting as a strategic city. First, is the lack of capacity city authorities within Sheffield and the surrounding region have over infrastructural matters. Like its European counterparts, the city of Sheffield does have the legal ability to create and manage its own energy network. However, cities in the UK do not have the general will nor the capacity to do so. Government cuts during a period of austerity means Sheffield does not have the funds to create its own energy or telecommunications network. The controversy over the South Yorkshire Digital Region project has damaged any enthusiasm for the city to become directly involved in infrastructural provision. Water supply and sewage within the UK remain regional monopolies, and without significant devolution (more than what is currently on offer), combined with widespread collaboration between neighbouring local authorities, it is difficult to imagine a situation where the water utility could be returned to public hands. These issues have shifted the meaning of infrastructure integration within the city of Sheffield, away from a focus on large technical networks and utility provision and towards areas in which the local authority has some degree of control: urban planning, economic growth, and facilitating forms of strategic cooperation. Integration in this sense is essentially a byword for 'alignment' within Sheffield: information sharing, organisational cooperation and a discourse on economic growth.

Second, within Sheffield there is a disparity between the theory of infrastructure integration amongst respondents and the actually existing practice of infrastructure integration. Many respondents spoke in favourable terms of infrastructure integration *as a theoretical concept*. Many believe that integration is, by definition, a good thing, something that is necessary for an urban area in which many disparate organisations often require joint partnership working and coordination to operate effectively. However, this belief in the beneficial nature of integration does not appear to translate into actually existing integrated working practices: utilities remain siloed from one another and from city authorities; investment portfolios are often disjointed with little regard to other projects that may be underway; and organisations remain 'selfish' in prioritising their own needs with little consideration of other bodies. While the local authority should be acting as a lead body in providing leadership and coordination to the myriad of infrastructural providers – a visionary strategic city – this appears to be piecemeal and only occurs at the individual project level, if there are project managers with a personal interest in integration.

As such, while the aim within Sheffield is to act as a strategic integrator, in reality the institutional context makes it difficult for any meaningful integration to be achieved. While Sheffield may have a

desire to become a visionary strategic city, currently it offers an example of what I describe as an *aspiring strategic* form of infrastructure integration. Using the conceptual framework developed in Chapter 2, this can be graphically represented in Figure 7.2.

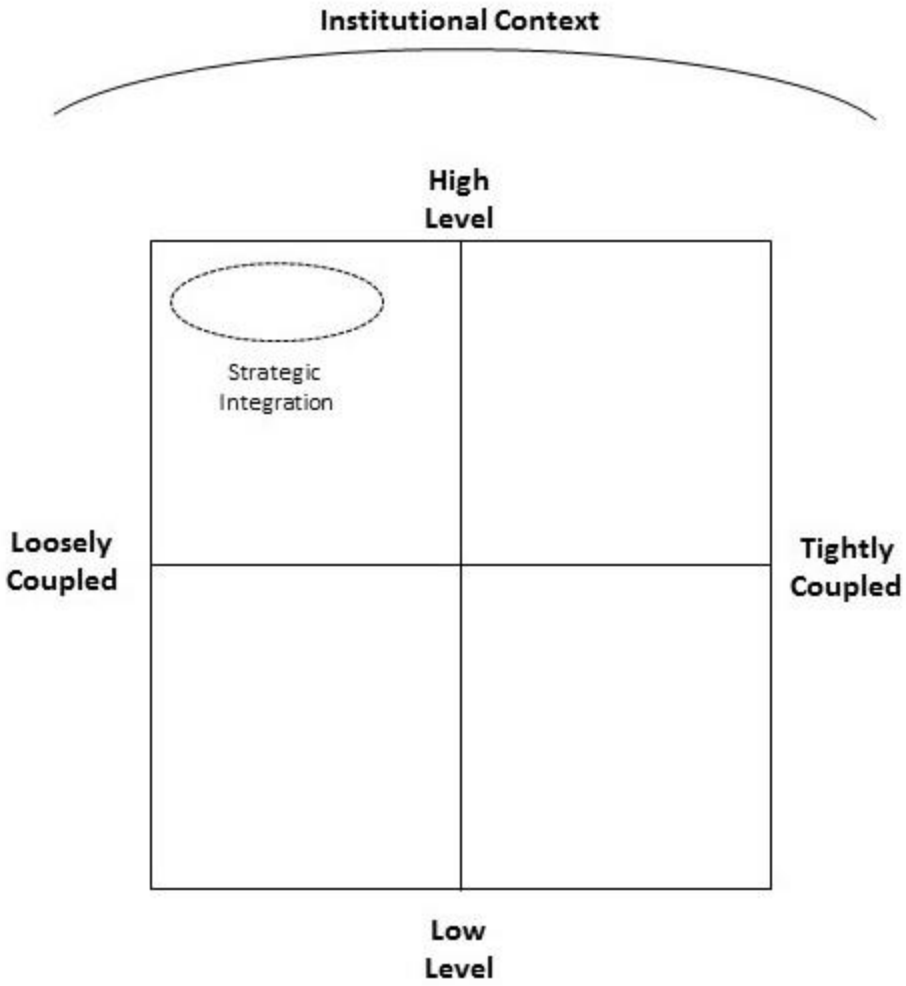


**FIGURE 7-2 SHEFFIELD'S ASPIRING STRATEGIC FORM OF INFRASTRUCTURE INTEGRATION**

The strategic nature of Sheffield's desire to act as an organisational lead and coordinating body in infrastructural matters means we can situate the form of infrastructure integration towards the top of the framework, as the decision-making networks between city officials and infrastructure operators, and the desired influence over private utilities, operate at a high-level within the city authorities. Yet the splintered nature of the UK's infrastructure services, and the reality that many infrastructure operators are large national companies that operate beyond the city boundaries, mean that any integration will remain loosely coupled and often siloed. The private operators will remain focused on their own core business. It is difficult to imagine a *Stadtwerke*-style organisation being created within Sheffield under the current institutional framework. The 'dotted' nature of Sheffield's conceptualisation of strategic integration in Figure 7.2 reflects the *aspirational* nature of

the concept – it is something that would be desirable in Sheffield, but it is arguably very difficult to achieve in practice. The inability for neighbouring authorities to agree on the devolution deal offered by central government also creates problems for integration to occur regionally. Neighbouring authorities view Sheffield with distrust, and a competing proposal to create a Yorkshire-wide authority is popular – only Sheffield and Rotherham remain committed to the 2015 devolution deal. Thus, it is difficult to imagine forms of 'tightly coupled' political integration occurring within the region.

In conclusion, Sheffield is a city that is constrained by its national institutional context that grants it little local autonomy, being unable to force through a concept of infrastructure integration that it sees as beneficial to the city, and is reliant on national utility companies that can often prioritise other cities for investment. While Sheffield has aims to become a strategically integrated city, a number of barriers remain that make this objective distant, remote, and aspirational.

# 8 CONCLUSION

This PhD has attempted to understand the growing urban discourse surrounding the concept of 'infrastructure integration' with an attempt to explore its meanings and implications through theory and practice. Through the examination of three case study cities (Seattle, Munich and Sheffield) I have attempted to examine the role of institutions, discourses and politics involved in urban infrastructural futures. This thesis has utilised a qualitative analysis of the three cities to provide empirical evidence on just what infrastructure integration may be. Throughout the PhD process I have conducted interviews with a variety of practitioners, industry actors, external consultants and those involved in the political process, and I have argued that the phrase 'infrastructure integration' is fluid, flexible, and inevitably partial in terms of the scale and scope of integration, but the term can carry positive connotations that can be overstated in project claims. It is also something that is dependent upon the institutional context in which decisions are made. In Chapter 2 I argued that the term 'infrastructure integration' could be described as a chaotic conception, something that may be "reminiscent of pre-scientific medicine. [It] may do good, but we have little detailed understanding of why" (Harrison and Donnelly 2011: 6). Or rather, it should do good, but there needs to be clear specification of what good it will achieve, where and why.

It has been my argument throughout this thesis that the three case study cities show three very different examples of intended infrastructure integration. In Seattle, this takes the form of *evolutionary* integration, an occasional operational necessity that emerges as a result of the day-to-day interactions of utility employees involved in infrastructural management. In Munich, it takes the form of *innovative* integration, or rather, infrastructure integration occurring as a result of the technological and social innovation processes inherent within a city with a strong civic ethos, a high mix of technology-orientated multi-national companies, and a high level of local authority independence. In Sheffield, meanwhile, integration can be described as taking on an *aspiring strategic* form, with the local public sector attempting to act as a coordinating and organising body to bring the disparate privatised utility operators together, however the ideals of infrastructure integration as something to be pursued is often different to what actually happens in practice. In this concluding chapter, I seek to bring this project to a close by summing up the main points addressed in this thesis, answering the research questions, and outlining the main contribution of this PhD. I begin this chapter with an outline of the key research findings.

## 8.1 KEY RESEARCH FINDINGS

This project began with four overarching objectives:

1) To develop a conceptual framework for researching urban infrastructure integration.
2) To examine perceptions of the rationale, opportunities and potential constraints for enhanced urban infrastructure integration in the three case study cities.
3) To investigate examples of effective urban infrastructure integration in the three case study cities, to understand what can facilitate integration and what can constrain it.

4) To contribute to wider conceptual discussions about the ideas and definitions of infrastructure integration.

To meet these objectives, it was important to translate them into a set specific questions that could guide the research process, each one seeking to address a key issue associated with infrastructure integration: its meanings, its context, its practices and its impacts.

1) What is meant by the term integrated infrastructure?
2) What are the capacities, opportunities or barriers for integration?
3) What is and is not being integrated in practice?
4) What are the likely social, economic and political impacts of integrating urban infrastructures?

In this section I seek to answer each research question in turn.

**1) What is meant by the term integrated infrastructure?**

The first research question aims to address the *meanings* of the term infrastructure integration. One of the primary goals of this PhD project was to open up the black box of infrastructure integration, to understand the meanings of the concept and to explore its applications in theory and in practice. The meanings of the concept has been explored in two stages: First, through identifying the meanings of infrastructure integration that emerge from a review of the academic literature, and second, through identifying the meanings of the concept that emerge through the empirical research.

In Chapter 2, I sought to define the key terms that underpin this thesis. It was important to start with a definition of what 'infrastructures' actually are, to identify what can influence them and to examine how they can have an impact upon society. I argue that there are three characteristics of infrastructures that are important to this research. First, that infrastructures should be viewed and analysed as socio-technical systems that are both socially constructed and society shaping. These systems do not exist outside of human society but rely on a number of externalities to become established and accepted within a culture. Second, socio-technical systems are embedded within wider institutional structures that can frame and shape their creation and development while also influencing their governance and operations. Socio-technical systems are themselves nested within wider governance networks and can be influenced by rules, regulations and cultures that can operate regionally, nationally and internationally. Third, while infrastructure networks can cross continents, it is at the urban scale that infrastructure interventions may have the most impact, as infrastructure networks and urban areas are inextricably linked.

Following this, I conducted a literature review on the meanings of 'infrastructure integration'. An understanding of the existing literature is necessary to create a theoretical underpinning to the research. I began the literature review with an exploration of the 'splintering urbanism' theory that can help situate the contemporary calls being made for integration, before examining a variety of

academic work that is important to infrastructure integration (the literature covering the 'nexus' of energy, water, and food, various 'smart' city debates, and the system of systems approach to infrastructural management). Drawing from this literature, I identified three primary features that appear to be common in discussions of infrastructure integration. First, infrastructure integration is almost universally viewed as something positive and an aspiration that should be worked towards. 'Integration' is seen as a way to create economies of scale between various sectors. It is often viewed uncritically and as an obvious way to solve a multitude of problems. Second, infrastructure integration can occur at a variety of scales. There are differences between the integration of networks within the home – using electric power to charge electric vehicles for example – and integrating large offshore wind projects into wider grid networks. To be effective, integration projects may need to operate on multiple levels and at multiple scales (EEA 2015a). Third, infrastructure integration can take a variety of forms, with the concept being difficult to define, contested, and often 'messy'.

Drawing from this literature, I created a working definition of infrastructure integration, which was outlined in Chapter 2 as:

> *The bringing together of technologies, actors or organisational structures (whether through changes in governance, operational practices or forms of service provision) at a variety of scales and forms that can lead to more sustainable, economic and resource-efficient infrastructure networks.*

While this definition is useful in providing a theoretical concept of infrastructure integration (being derived from the literature that cites its importance) it remains a theoretical definition until it is tested in the real world. Chapters 5, 6 and 7 sought to do this by examining the interviewee perceptions of infrastructure integration within each case study city. The meanings of infrastructure integration that emerge from this research arguably reflect the institutional culture and the infrastructural discourses of the city in question. There are two issues that emerge from the empirical research important to the meanings of infrastructure integration.

First, the meanings of the concept evident throughout the empirical research do appear to reinforce the definitions evident within the academic literature discussed in Chapter 2. While each city has its own infrastructure priorities and specific institutional environment that can structure what actions can be taken, the belief that infrastructure integration can lead to sustainable, economic and resource-efficient networks is evidenced in all three case study cities. However, there is considerable disagreement as to what 'scale' integration may occur at and what 'form' it should take. While the definition outlined in Chapter 2 is a useful overarching description of what infrastructure integration may entail in general terms, there is variation when examining specific examples. In Seattle, respondents saw infrastructure integration as a way for the city to meet social and environmental goals, such as through the creation of utility discount programmes or by 'integrating' climate change mitigation efforts into every aspect of urban design (Rice 2010). While there is disagreement over the need for high-level forms of integration – such as through the joining up of the energy and water utilities – there is little disagreement over the benefits associated with the creation of integrated front office services for residents. In Munich, respondents spoke of their desire for the city authority to pursue infrastructure integration in order to act as a holistic guarantor of services to improve sustainability and create a high quality of life for residents. While Munich and Seattle share

aspirations in creating environmental sustainability and improving social equity, they differ in their views as to how infrastructure integration can lead to their goals. In Sheffield, meanwhile, the economic benefits of infrastructure integration were at the forefront, with the view that the public sector should act as a strategic overseer of urban infrastructures that can direct investment and economic growth into specific areas, rather than being a direct provider of those infrastructures. While there are key differences in how each city views infrastructure integration, the interviewees (mainly) agree that various forms of integration are beneficial.

The second meaning that emerges from the empirical research is the lack of discussion over the technological aspects of integration. One key feature of the definition emerging from the academic literature is that new technology is often cited as a way to enable forms of infrastructure integration. Yet, while 'smart city' and 'smart energy grid' discourses are focused on how new technologies can enact change, there is very little of this discussion amongst interviewees. Part of this may be due to the nature of the work conducted by the interviewees chosen for this research – they are often urban planners and infrastructural managers who may not be concerned with the minutiae of detailed technological developments. However, it may also suggest that the calls being made for technologies that could lead to forms of integration are being overplayed. What has emerged in this research is that other forms of infrastructure integration are more important: low level forms of information sharing, the importance of organisational integration through partnership working, and changes to working practices within and between organisations. While Munich's Limux project does focus on technological change, this is arguably more a rejection of the off-the-shelf products being promoted by global companies such as Microsoft. Instead, it is the ability for the city authority to control its own internal structures and encourage economic growth within the city that is important, rather than providing technology simply for its own sake.

### *2) What are the capacities, opportunities or barriers for integration?*

The second research question emerges from the need to examine the *context* of infrastructure integration, and to examine how the institutional environment can structure the capacities, opportunities and barriers for it to occur. As highlighted in Chapter 2, a key feature of the conceptual framework is an acknowledgement that the types of infrastructure integration that emerge are context-specific, contested and embedded within the institutional and socio-political culture of the city in question. The geographical and historical context of cities is vital in shaping how they can respond to particular developments or innovations (Bulkeley et al. 2016). It is difficult for cities within the UK, for example, to pursue forms of infrastructure integration at an urban level, as the privatised nature of key infrastructures makes it difficult to enforce cooperation between the various national utility providers. In contrast, the prevalence of the *Stadtwerke* model in Germany offer cities input over their infrastructural choices that may be difficult to envisage elsewhere.

Because of this, it is important to examine the institutional environment of the three case study cities and in Chapter 4 I examined the national regulatory and political cultures that structure their governance. Drawing from this literature, as well as from the results of the empirical research outlined in Chapters 5, 6 and 7, it is possible to identify the capacities, opportunities and barriers for

infrastructure integration. It should be recognised that, while there are clear differences in infrastructure governance between nations, it is also likely that there are differences between cities within the same country. Seattle, for example, is facing different infrastructure challenges and opportunities than Denver or Austin, while Sheffield has different abilities and powers to act than London. As a result, the capacities, opportunities and barriers that exist in relation to infrastructure integration are context-specific to the city under analysis. I will examine each of the case study cities in this section.

### SEATTLE

In the US, the federated governance system means many infrastructure decisions are taken at the state or city level, with a federal government unable (or unwilling) to force its will on the largely autonomous states. This offers states and cities a degree of freedom over their own infrastructural choices, and it does allow them to act quickly when new innovations (whether technological or organisational) offer the potential to improve current infrastructure arrangements. As such, if states or cities have a preference to move towards forms of infrastructure integration then arguably, they have the ability to do so. Infrastructural choices can therefore be locally tailored – witness the differences in waste management practices between southern states and northern states as outlined in Chapter 4. However, the lack of a strong federal centre makes it difficult to pursue infrastructure integration at a national scale. Instead, infrastructure policies are a 'patchwork quilt' across the country, with different states able to pursue different policies towards different ends. If infrastructure integration is to be pursued, it is likely to be a decision taken at the local level.

Within this national framework, cities appear to be the most appropriate scale at which infrastructure integration should be analysed. At first glance, Seattle appears to be a city with an ideal conducive environment for innovation in urban integration. Geographically the surrounding mountain and glacial areas provide the city with clean renewable hydro power; the urban economy is dominated by global high-tech companies such as Amazon, Microsoft and Boeing, providing a highly educated and politically active citizenry; and the main utilities are publicly owned by the city authority. It is the combination of these features that led to Seattle being chosen as a case study for this project – if we are to ask the question 'how is X possible', then we should examine cases in which the preconditions for 'X' appear more clearly than others (Danermark et al 2002).

However, while the institutional structure appears to be conducive for forms of infrastructure integration to occur, it seems there are two key barriers that act against it. First, integration does not appear to be a priority for the interviewees involved to this research. While in the main some forms of integration are seen as beneficial, a number of actors within the city's departments appear to dislike the concept of large-scale integration entirely, believing the separation of infrastructures allows for a focus (both in engineering and financial terms) on what is important for that particular infrastructure, preventing engineers from getting side-tracked with other projects unrelated to the utility's core nexus. As one interviewee said:

> "If everything is kind of integrated it's hard to tell where I stop working and you begin. The dance is so tight that you can't really tell my part from your part" (interview, City of Seattle director).

Adding to this, many actors see various forms of integration as simply unnecessary. For many interviewees, the current framework appears to work well and radical changes to governance

structures are simply not needed. The strong environmental goals set by the City of Seattle can be met under the existing socio-technical environment without any disruptive change.

The second barrier to integration is the regulatory system within Washington State. In many ways, infrastructural governance within Seattle reflects much of the academic literature describing the modern networks as splintered and siloed (Graham and Marvin 2001). However, while the splintering urbanism thesis describes the impacts of privatisation on large infrastructure networks, in Seattle it is the regulatory structure that acts to prevent forms of integration, which I described in Chapter 5 as *judicial splintering*. The legal separation of the water and energy utilities (being classed as single-use enterprise funds) makes it difficult for any high-level forms of integration to occur. While a previous example of organisational integration led to the creation of Seattle Public Utilities in the 1990s, the water utility must remain a legally separate entity. This can create problems when new technologies are leading to calls for forms of infrastructure integration to occur. New 'smart' energy grid technologies, for example, cross the boundaries between energy and telecommunications yet the regulations prevent Seattle City Light from funding any broadband network that can be managed as a separate telecommunications utility, making it difficult to 'smarten' the existing energy grid. Yet, if we accept that infrastructure integration can occur at a variety of scales and in a variety of forms then the combined governance and management of city infrastructures may not be necessary to work towards more sustainable, economic and resource-efficient infrastructure networks. The nature of Seattle's institutional framework allows it to meet these goals in other ways – the judicial splintering may restrict forms of strategic integration, however it does not appear to work against creating sustainable networks.

It is also important to note that it is arguably the *belief* of key actors within Seattle that it is not possible to create a city-owned telecommunications utility, rather than the actually existing reality. The nearby city of Tacoma does operate a publicly-owned telecommunications utility while operating under the same regulatory system as Seattle. It may be that actors within Tacoma have different views on the ability of the city to offer services than those in Seattle. A future research project may seek to answer why this is the case.

### MUNICH

Like Seattle, Munich was chosen as a case study for this research due to its reputation as a city with strong institutional frameworks for urban governance and as a city that is actively pursuing and supporting various forms of infrastructure integration.

Also like Seattle, the progression of infrastructure integration is arguably constrained due to the regulatory barriers that place restrictions upon state-owned enterprises. The liberalisation policies of the European Union to create competitive markets within the energy sector act in much the same way as the accountancy regulations within Seattle: state-owned energy enterprises (such as that operated by the SWM) must be funded from energy-related income without any form of cross-subsidisation. While the laws are similar, there are very different motivations behind the regulatory structures of the two cities. In Seattle, the accountancy laws in the state of Washington are designed to tackle corruption, while in the European Union the focus is more on free market competition. Yet while these regulations may act as a barrier for infrastructure integration, the innovative technological milieu within Munich formed by the mix of high-tech companies and consensus-

seeking form of democracy, combined with the decentralised decision-making structures within urban governance and the ability of system builders to act in experimental and innovative ways, provides for niche-type experimental zones to emerge, both in terms of technological developments and in terms of new organisational forms of working. The Limux IT project offers a clear example of the city's ability to trial technologies while the Inzell Initiative offers an example of innovative organisational practices. Both projects were created to tackle perceived failures of existing institutional models and both were given space to emerge, evolve and eventually become part of the urban discourse. As Hajer and Kesserling argue, the Inzell meetings:

> "…allowed for a conceptual renewal in a very short period of time. The Inzell process gave rise to a new discourse-coalition: it cut through the existing formations of interest and problem perception. The redefinition of the problems involved, and the accompanying creation of new perspectives for the various interested parties, were seen as a turn for the better by most participants. In this sense the Inzell meeting gave way to new networks that cut across the various municipal departments and included various groups from business and industry as well as experts from the university" (Hajer and Kesselring 1999: 11).

The strong links and partnership working between industry, business and urban officials in managing and innovating the city's infrastructural networks is arguably a result of the "social systems of innovation and production based on powerful public intervention by centralised bodies or local authorities" at work within the German state (Bolognesi 2014). The forms of innovative integration that exist within Munich reinforce Lorrain's concept of German 'pragmatic municipalism' (2005) and the incremental nature of German capitalism. The lack of top-down ideological pressures from national government, combined with the federated nature of the German state, allows the city of Munich to design context-specific forms of infrastructure governance while abiding by the federal constitution's desire to "ensure equal living conditions on the territory of the Republic" (Wollmann et al. 2010a). The 'socially embedded capitalism' that attempts to incorporate the market economy into the reaches of the state with a strong ethos of state-led social reform (Lehmburch 2005) is evident within Munich's concept of acting as a holistic service provider. City officials retain a degree of control over planning regulations and urban developments; the concept of internal expansion rather than urban sprawl, and the development priorities of 'compact, urban and green' permeates through all city departments; and the SWM's commitment to high-quality, low-cost and environmentally sustainable provision of services goes beyond the simple profit motive inherent in private competition.

### SHEFFIELD

Unlike Seattle and Munich, Sheffield was chosen as a case study city as it is a city that may find it difficult to move to more integrated ways of infrastructural management. The UK's infrastructural environment is splintered and siloed (Graham and Marvin 2001), many providers are privately owned and managed at a national level, and cities have little authority or ability to act within the highly centralised UK state. This institutional landscape means that city authorities often act merely to implement policies imposed upon them by central government, and it is clear from the research that the priorities in Sheffield are on economic growth and competitiveness rather than on social equity and sustainability. There are three main features of Sheffield's institutional landscape that shape forms of infrastructure integration.

First, the resources available to local authorities within the UK come primarily from central government and the restrictions attached to much of the funding – such as the ring-fenced education budgets – means local authority finance is already 'pre-splintered' at source. There is little autonomy for cities such as Sheffield to adjust budgets that are often set centrally. While devolution has led to the creation of a Local Enterprise Partnership, a combined authority, an upcoming elected mayor, and some relaxation of the restrictions attached to funding, it appears that any meaningful change in terms of infrastructural governance will be incremental and slow. While the devolved powers are welcomed by many interviewees in Sheffield, the level of actual authority and additional finance that these new authorities will have is debatable. Many devolved powers relate to transport and urban planning, with little ability to influence infrastructures such as energy, water or telecommunications. Also, while an investment grant of £30m a year is beneficial in allowing the Combined Authority to develop its own priorities, in reality this money is still reliant on the consent of central government (after five-yearly reviews) and, as such, may be removed, changed or cut at any time. In actual practice the £30m annual grant may not make up for the budgetary cuts imposed on local authorities since the election of an austerity-driven coalition government in 2010, and it is likely that in the short term the devolution changes in local governance may not be as revolutionary as some commentators claim.

Second, the sectoral infrastructure model that operates within the UK and the fact that many investment decisions are made at a national level makes it difficult for actors within Sheffield to influence infrastructure providers. The energy, water and telecommunications utilities view Sheffield City Council as just one stakeholder of many, and the level of authority city officials have over infrastructure operators can be minimal. One example is the difficulty faced by the Combined Authority in persuading utility representatives to attend meetings of the LEP. Another is the concern over the restrictions attached to highways remedial action under the Streets Ahead contract – if providers are forced to fund the remedial works after digging up roads to lay pipes and infrastructure then, as one interviewee argued, they are likely to prioritise investment elsewhere.

Third, while cities within the UK have the theoretical ability to create their own new infrastructure networks, the experience and failure of the South Yorkshire Digital Region makes it unlikely that any similar scheme will be pursued in the future. The escalating costs, the level of bureaucracy involved in having several local authorities involved in the project without a clear organisational lead, and the resulting drop in investment from private competitors, all contributed to the project's failure. Although a number of respondents said there was nothing in law to prevent the city from creating its own energy utility, in reality there seems to be little appetite to pursue such a course of action.

### *3) What is and is not being integrated in practice?*

The third research question aims to address the actual *practices* of infrastructure integration. The discussion so far in this chapter has focused on the meanings of infrastructure integration and what can enable or constrain it. In this section I wish to discuss the actual practices of infrastructure integration that emerged in each city. To help with this analysis, in Chapter 2 I developed a conceptual framework which can be used to situate the various forms of infrastructure integration

that emerged from the empirical research. Drawing on the findings, these three forms can be graphically represented in Figure 8.1.

It should be noted that each city offers evidence of different forms of infrastructure integration. Its application within each city is different, the discourse surrounding the beneficial outcomes of integration varies, and the term is largely context-specific. The varying backgrounds, disciplines and experience of actors involved in infrastructural decision making can alter the definitions of integration and can influence how it will (or will not) be addressed. The three forms that emerge from the empirical chapters will be explored in this section: the evolutionary form of integration within Seattle, the innovative form within Munich, and the aspiring strategic form in Sheffield.

In Seattle, infrastructure integration appears to occur only if it is required or necessary on an individual project basis, and it is the employees engaged in infrastructural matters that will decide this. In Chapter 5 I described this as an *evolutionary* form of infrastructure integration: integration is not something imposed on engineering staff from above by political actors (apart from the clear political desire to streamline the organisational chain of command, as seen in the creation of Seattle Public Utilities by Mayor Norman Rice). Rather, evolutionary integration refers to the piecemeal progression of various policy implementations that are required on a day-to-day basis to improve the efficiency of infrastructural governance, such as in the creation of SPU's comprehensive asset management programme or in the city-wide creation of the Capital Improvement Programme that involves the integration of project planning within the city's departments. This form of evolutionary integration can be situated within the centre of the conceptual framework in Figure 8.1, as it mostly emerges from the day-to-day operational concerns of individual project managers. The judicial splintering that occurs at the state level creates a degree of regulatory independence between each domain, and there is little overt top-down pressure to integrate the city utilities at a strategic level, however the cross-sector working inherent within the city authorities means the coupling is not entirely 'loose'. The lack of desire and lack of incentive for the city to undergo radical change leads instead to incremental change that may result in a more integrated structure only if this is necessary to improve the already efficient and sustainable management of the existing technical networks, and only if it is possible under the tough regulatory restrictions imposed by the State of Washington.

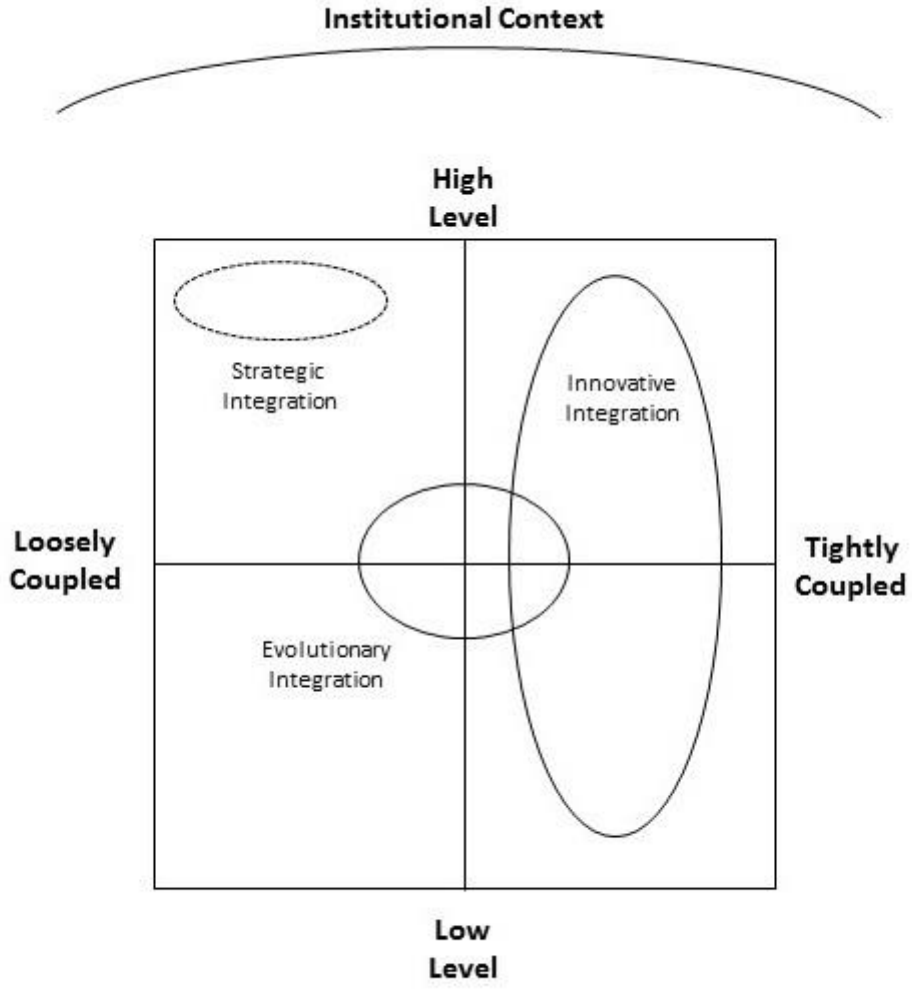


**FIGURE 8-1 THREE FORMS OF INFRASTRUCTURE INTEGRATION**

Munich's form of *innovative* integration, or *integration as a result of innovative processes*, refers to the *processes* of infrastructural management and the general direction towards a more integrated future, rather than in signifying a fixed end point to strive towards. It is the journey towards integration rather than the destination of a final integrated urban whole that is important here, and it may be that the city will never be wholly integrated in organisational, technological or social terms. Infrastructure integration within Munich refers to the inclusion of disparate entities in decision-making structures, bringing in private partners to discuss potential urban futures, and through forms of deliberative democracy that offers citizen input within governance networks. While Munich's city authority can be said to act as a holistic, pragmatic provider of services, the concept of infrastructure integration is more focused on the direction of travel for city departments rather than being a fixed, final goal. Unlike in Seattle, the prominence of the discourse of infrastructure integration within the city means it covers a large area within the conceptual framework in Figure 8.1. The strategic desire to pursue integration leads to it occurring at a 'high-

level', and this filters through city organisations to those involved in the day-to-day operational concerns. Also, the mix of private and public cooperation, as well as the S*tadtwerke* model promoting forms of cross-sectoral working, provides for a 'tightly coupled' form of infrastructural governance, even taking into account the European competition laws that prevent cross-subsidisation.

In Sheffield, meanwhile, infrastructure integration is something more diffuse and is something that is more difficult to achieve. Rather than attempting to integrate the various infrastructures together – a task that is difficult, if not impossible, in the splintered and competitive UK marketplace – actors within Sheffield see infrastructure integration as a way for the city authority to become a proactive operator within the urban arena. The local authority, it is believed, should act as a *strategic* organisation, a magnet or a focal point around which other organisations can align. Direct provision of infrastructures is not necessary. In a sense, the lack of authority the city council has over infrastructural decision-making has somewhat relegated the public sector to act in this top-level, hands off, manner and almost forces it to view the city as a collection of systems that should link together: it arguably has no other option but to act in this strategic planning role. It has become an organisation that can often only act to incentivise rather than directly provide, to help bring other disparate organisations together and to coordinate various integrated partnerships. While moves to create a combined authority that cover the city region may offer forms of organisational integration (operating at the strategic 'high' level within the conceptual framework) the difficulties associated with its creation, and the lack of any ability to coerce the national infrastructure providers to participate in organisations such as the LEP, means the form of strategic integration remains an aspiration rather than an actual reality. While the city may aspire to act as a strategic visionary authority, the reality in practice is more problematic as Sheffield lacks the authority needed to act in this way and cannot compel organisations to cooperate.

These aspirations of Sheffield in acting as a strategic organisation can become problematic when they meet the reality of a lack of resources and authority. As discussed by one interviewee in Chapter 7, there is no one working on forms of high-level strategic integration within the authority. Instead, the infrastructure integration that does occur appears opportunistic, in that it only occurs when officials can pursue it through individual projects when funding becomes available. The Streets Ahead PFI project offers one example, in that the team created to manage the information sharing and operational management of the project are only tasked with integrating the tasks necessary for the individual project. Integration is restricted to the organisation of project-specific tasks: ensuring departments and external organisations are aware when construction projects are to be carried out so they can align their own investment priorities. The attempts at strategic integration that are made – such as through the creation of the city centre masterplan documents – lack the level of authority of similar plans created in Seattle and Munich. While Sheffield's plans do outline where growth should occur and what infrastructures need to be in place for growth to occur, planners can become reliant on either the private utilities being willing to align their own investment portfolios with the city council's, or on contributions from individual developers. This reduces the urgency within the plans and there are little sanctions the city authority can impose on external organisations unwilling to cooperate.

It should be noted that these three forms of infrastructure integration – evolutionary, innovative, and aspiring strategic – are context-specific and are situated within the existing institutional

structures of their host cities. It is unlikely that the evolutionary form of integration found in Seattle will translate easily to other US cities such as New York, Denver or Chicago, let alone to cities within the UK or Germany. The different socio-political cultures that exist within each US state will create different priorities for different cities in different areas. Similarly, the innovative forms of integration found in Munich may be different to those found in Berlin or Stuttgart. The Limux project and the Inzell Initiative both arose out of the particular set of circumstances found in Munich at that particular time and place. It may be that Berlin has no need to create its own IT operating system, and the economic situation in Stuttgart may work against attempts to create partnership agreements with a range of innovative technology companies.

Yet, despite this caveat, there are a number of similarities in how infrastructure integration can manifest within the three case study cities. In this section I wish to highlight two: the vital role played by the public sector in infrastructural concerns; and the operational necessity of pursuing forms of 'mundane' infrastructure integration.

The first similarity is that, while each city differs in its institutional context and ability to enact change, in practice it appears that all three cities view their infrastructures as a system of systems – a collection of interdependent subsystems that interact with each other to create a stable whole. Also, despite their clear institutional differences, actors in all three cities believe that it is the public sector that should take on the role of a strategic 'overseer' in governing that system of systems. While the ownership of each socio-technical system may differ (e.g. private utilities in Sheffield, public utilities in Seattle and Munich) it is argued that only the public sector can view the entire city as an urban whole, that can step back from the day-to-day operational concerns of each infrastructure and view the city as a larger collection of component parts. The actual ownership model that governs each individual infrastructure is largely irrelevant. Indeed, it may be that infrastructures can function optimally when only loosely coupled to each other (Rinaldi et al. 2001). Instead, it is the organisational ability of the public sector lead authority that is able to coordinate and align different projects pursued by disparate groups, maintaining the separation and 'splintering' of infrastructures yet allowing for data sharing and project alignment. This role manifests itself through the use of urban masterplan documents. The Capital Improvement Programme in Seattle is an example of this occurring in practical terms ("when I look at how we are integrated with other departments, probably one of the biggest things we have is the capital improvement committee that goes across all departments", interview, City of Seattle director). Munich utilises the Munich Perspective masterplan document in the same manner, which acts as a "strategic, proactive urban development concept" that promotes a cooperative and communicative process of "managing uncounted interdependences in an open field of actors of the civil society, the market economy, the different levels of the political-administrative system and the democratic decision process" (Thierstein and Reiss-Schmidt 2008: 1). Sheffield's masterplans meanwhile, provide the "physical development and delivery framework to achieve the economic transformation of Sheffield in accordance with strategic policy objectives" (SCC 2008).

In many ways, these urban masterplans provide examples of how integration can work in practice. They are designed from the outset to improve information sharing between internal and external departments and to facilitate a coordination of construction work to minimise cost and disruption to residents. They provide an avenue for actors to align and cooperate to achieve shared goals, and can offer urban authorities a level of democratic input into future growth and investment. In Seattle,

both the energy utility's Comprehensive Asset Programme and the city's Capital Improvement Plan are designed to increase integration to improve the quality and efficiency of governance chains in terms of the timescales involved in organisational decision-making and to reduce the end cost of construction projects. The integration that occurs here is viewed as so beneficial by department managers that one suggested the frequency of meetings should be increased from twice a year to once a month (interview, City of Seattle director). The Sheffield Plan offers a 'shared vision' that "aims to give clarity, direction and confidence to partners in the private and public sectors" (SCC 2008: 3). This clarity can only be achieved through "effective partnership working" between the various local authority departments and private utilities. For Sheffield in particular, the creation of masterplan documents (although required by law) does allow city officials to have a degree of authority over infrastructural matters that is otherwise the purview of private utility companies. City officials can plan where economic growth should be focused, discuss what infrastructures the city needs to facilitate that growth, and offer an avenue to bring external organisations together. Without the processes involved in the creation of masterplans it is arguable that city officials will have little input to the investment priorities of the private utilities.

The masterplan documents in all three cities, although differing in their emphases and tailored to their own locales, are examples of infrastructure integration, providing focal points and priorities for citizens, state actors and private organisations to interact with. This meets the definition of the concept developed in Chapter 2, in that masterplan documents can facilitate the *bringing together of technologies, actors or organisational structures* to enable sustainable, economic and resource-efficient networks.

The second form of infrastructure integration that is common in all three cities is the often overlooked yet vital forms of integration that emerge as a result of the routine, everyday operational practices within infrastructures. This refers to the mundane, day-to-day workings of various actors, data sharing between various departments and between the various privatised utilities, and the creation of cross-sector partnership groups that coordinate investment activities. The cross-departmental teams within Seattle are a good example: the teams involve two-way communications between departments but are comprised of workers who may view integration as a side project and something that can benefit them in their day-to-day activities rather than as a primary goal of employment. Sheffield's Streets Ahead project is another example: rather than being an 'integration' project from the outset, the team partnership working evolved as a necessity of handling a complex PFI project and the need to provide lines of communications between departments and utilities. This is not an 'integration' project per se, but it is a project that needs forms of integration to operate effectively. Although the effectiveness of each project can be debated in isolation, the forms of infrastructure integration discussed here are necessary and arguably inevitable.

While there are similarities in what is being integrated, what is not being integrated can be just as important. There is little desire for large-scale disruptions to existing working patterns in order to create more integrated working. There is little desire within the three cities for the creation of a single MUSCo-type organisation to manage an entirety of a city's infrastructures. Indeed, the regulatory barriers that exist within Seattle and Munich make it difficult to integrate energy and telecommunications in order to enable 'smart' grid technologies. The 'splintering' discussed within the splintering urbanism thesis does appear in all three cities, albeit in different forms. However, it needs to be acknowledged that even taking into account the splintered nature of many

infrastructures, nothing is entirely separated. Even the most 'loosely coupled' infrastructure will have some degree of integration with other sectors. Similarly, nothing is entirely integrated. What has emerged from this research is that there is no one-size-fits-all approach to infrastructure integration. It is context-specific and emerges within the existing institutional context.

### *4) What are the likely social, economic and political impacts of integrating urban infrastructures?*

The fourth research question relates to the potential *impacts* of infrastructure integration. There are three issues that I wish to highlight.

First, the forms of infrastructure integration occurring within the three cities do appear to have benefits in terms of economic efficiencies, providing for an increase in local state control over infrastructure, and in terms of social equity. In Munich, the shift to an in-house software suite through the Limux project has saved the city authority an estimated €11 million in software licences, hardware upgrades and training (Essers 2012). The project has also started a discourse on creating context-specific software solutions, as well as opening the city departments up to cooperation with the local business community to design and implement locally-tailored software solutions. This form of internal software integration, which could have simply become a back-office upgrade to the city's IT infrastructure, is instead seen as an opportunity to meet overarching city goals of native economic growth and business development. Munich's SWM shares similar goals in terms of social equity and its attempts at geographic integration (such as creating national virtual power plants and investing in renewable plants abroad) is aimed at providing Munich residents with a higher share of renewable energy. In Munich integration is viewed as something that can be used to create benefits for the urban population. A similar point can be made about Seattle's Utility Discount Program, which can lower a customer's energy bill by 60 per cent and bills to SPU by 50 per cent. This form of social integration allows for combined contracts for poorer residents and the integration of other infrastructural services into front-facing organisations that could allow for further social equity goals to be pursued by democratically-elected city councillors. The integration occurring as a result of Sheffield's Streets Ahead project meanwhile, is designed to improve efficiency in coordinating the various teams involved in street works. However, many of these forms of integration appear to be so obvious that they arguably do not deserve comment. The sharing of GIS datasets between project teams involved in laying street pipes, for example, should be routine in any public sector organisation.

The second potential impact, however, is the potential for infrastructure integration to close down discussions over infrastructural futures and to restrict the input of those without privileged access to certain groups. One issue with the forms of infrastructure integration that have been discussed throughout this project is the application of power. If, as I have argued above, urban masterplan documents can act as a vehicle in which to pursue various forms of infrastructure integration, then it is important to query just how open the creation of these documents actually are in terms of democratic input from those outside accepted circles. While in theory a council-managed masterplan document does allow for input from elected councillors and residents, in practice the technical and nebulous nature of many documents may make citizen input difficult. Masterplan

documents in many cities are often vague outlines of potential growth zones and high-level mission statements about the future of 'smart' and 'resilient' cities. Very rarely do they contain detailed technical statements outlining the specific type of growth that will be facilitated. Often this can be to keep contentious and highly political statements away from politicians – detailed plans to provide new housing for newly arrived immigrants or new wind turbine parks may provoke conflict between local political parties. In Seattle, it is also the belief that city councillors seek short-term impacts over sustainable but less politically rewarding changes to the urban fabric, and officials have arguably tried to move infrastructure decisions away from the political arena. Once the city council has approved the initial six-year plan it is difficult for individual projects to be re-opened and funds shifted from one project to another. As one interviewee said, the ability to reduce democratic input into infrastructural matters was one factor behind the development of joint asset plans: "Far be it from me to question what the council and the mayor does: the people elect them and that's how it operates. But we are trying to figure out is there some way we can get around that…" (interview, SPU executive). Similar points have been made by Hajer and Kesselring, who argue the consensus-seeking inherent in Munich that leads to projects such as Inzell can create slow and arduous decision making chains that can be non-contentious while paying "lip-service to the new democracy" (Hajer and Kesselring 1999: 14). As Hajer and Kesselring argue industry is in "a position to exert considerable influence, not only in terms of framing the issue of mobility but also in suggesting strategic solutions to the 'problems'" (Hajer and Kesselring 1999: 14). While the form of strategic integration that occurs within the three case study cities can be well integrated, well intentioned and an obvious way to create strategic goals and objectives, difficulties can arise when practical actions are filtered down to operational scales, when the emphasis shifts from democratic discussions to implementation only which can overlook the potential for localised levels of input (Niekerk and Arts 1996).

A third issue is the lack of support for radical changes in how infrastructures are owned, managed and delivered. No city examined in this thesis appears to have any desire to radically alter the institutional structure and ownership models of their infrastructures. It is significant that interviewees rarely spoke in favour of large-scale disruption, and many saw the existing institutional framework as something to work within, rather than something that needs to be changed. It may be that returning infrastructures to a monopolised structure owned by the public sector is the most efficient, socially equitable and environmentally sustainable way of service provision. However, there does not appear to be any desire to move towards such a system. While Seattle and Munich do have city-owned infrastructures, they remain splintered and managed as independent entities. In the main, participants from all three cities spoke in positive terms about the institutional structure they operate within, Discussions often centred on small incremental changes – an increase in the sharing of GIS datasets between city departments, further information sharing between the public and private sectors, and the creation of joint working groups are all viewed as important practices to improve infrastructure integration in all three cities. This low-level integration can occur within existing institutional frameworks and do not need radical changes in infrastructure ownership. There appears to be little demand to create a MUSCo-type organisation, while new technologies (such as decentralised generation or 'smart' controls) are often viewed as products that can operate alongside existing networks, rather than replacing them entirely (at least in the short term). This may be due to a subconscious bias amongst the interviewees in expressing support for integration to occur in fields in which they have a degree of control over. The preference for low-level forms of

integration may reflect the positionality of the individual interviewees and their inability to enact more radical forms of infrastructural change. It is difficult to envisage, for example, individual managers within Sheffield being able to force the privatised utilities to act in more 'integrated' ways, let alone argue for wholesale changes to the wider infrastructure landscape (which, in the UK, is mainly governed at the national scale). Indeed, there is little discussion evidenced within this research on the demand to do so. This might also explain the enthusiasm shown in all three cities for urban development masterplans, and the ability for these documents to encourage and promote forms of infrastructure integration. Urban plans can be used as pivot points around which organisations can align their own investments and prioritise projects, helping to create more 'integrated' working practices. Importantly, these plans are developed at the urban level, and urban areas are themselves nested within larger institutional networks. Those involved within infrastructural management on an urban scale may find it difficult to enact change at a national or international level – witness the lack of pressure to change the accountancy rules within Washington State or the European laws pushing for the liberalisation of energy markets. Actors may find it more fruitful to influence the creation of urban masterplans documents (by seeking tougher regulations on the sustainability of new developments, for example) rather than calling for new entire infrastructure ownership models or changes to national or international regulations.

While there are shifts in some areas that may allow for different forms of integration to occur in the future – such as through the creation of the Combined Authority in Sheffield – it is likely that any changes will be incremental and slow. In many ways, Sheffield is a city trapped by its institutional framework. Further integration could indeed be beneficial for the city and there is an opportunity to see the urban area as a holistic system of systems, and although there is limited scope for the direct provision of infrastructural services, the splintered networks could benefit from an increase in centralised coordination and planning. While several utilities have been reluctant to cede authority to the city council (as discussed in Chapter 7) the further integration at the strategic level could benefit the city in terms of economic development, social equity (such as through the provision of improved broadband networks) and a re-articulation of local state authority. Yet, despite this, there is a sense amongst interviewees that it is more fruitful to pursue integration within existing frameworks, rather than changing the institutional framework to allow for integration. One argument within the academic literature is that improving the integration of infrastructures could be one way to lead to more sustainable and resource efficient cities, and that this can be done within existing institutional frameworks. As Williams et al argue:

> "The concept of 'integration' has become a panacea for the negative aspects of the nexus, an ultimate solution that forestalls more politically informed discussions. This assumed logic ultimately implies that the serious challenges posed by the nexus framework, do not in fact require real political change" (Williams et al. 2014: 5).

However, if there is to be *real* political change, then it is likely that this will occur not just as a result of a desire for infrastructure integration, but as a result of other, more fundamental concerns. Infrastructure integration, it seems, has a surprising lack of radical impact.

## 8.2 Contribution of The Thesis

The aim of any PhD thesis is to contribute knowledge in its field (Dunleavy 2015). This thesis has contributed in three main ways.

The first area relates to the primary purpose of the project – attempting to open the black box of infrastructure integration and to explore its meanings in theory and in practice. As has been stressed throughout this thesis, it has become accepted knowledge within academic and policy circles that integration is beneficial and should be a key aim for cities to become more resource efficient, sustainable, and socially equitable. What has become clear though, is that this does not encapsulate the whole story. *Some* forms of infrastructure integration *may* indeed lead to beneficial outcomes, however this is certainly not a given. As I have argued throughout this thesis, there are different forms and scales of infrastructure integration, and the extent of their success depends on the institutional structures and socio-political cultures that exist in certain places. I have demonstrated this through the creation of the conceptual framework discussed in Chapter 2 that highlights the many forms of integration that could occur – whether tightly or loosely coupled to other infrastructures, or occurring at a high strategic level or a low operational level. There is no single 'integrated' outcome, but a multiplicity of forms depending on where integration is being pursued, by whom, and to what ends.

The second, and linked, contribution relates to an attempt to broaden current infrastructure policy and a recognition that, while the literature claims infrastructure integration may be beneficial and something to aspire towards, infrastructure integration is inevitably partial and the possibility for – and focus of – integration is likely to vary between international and local contexts. What works in one city may not necessarily work in another. It is very difficult, for example, to envisage the high-level strategic form of infrastructure integration occurring in Seattle, as the regulatory structures in Washington State specifically act against forms of cross-subsidisation. Similar forms of integration are also difficult to pursue in the UK, as the privatised nature of many of the country's infrastructure sectors and the national scale that many operators work within make it difficult for individual cities to act on their own. It needs to be recognised that there are many forms of infrastructure integration that can occur at varying scales. Integration should not be pursued simply for integration's sake. Policymakers seeking to pursue forms of infrastructure integration should be aware that its success depends on a multiplicity of factors, and should take into account existing socio-political cultures before evaluating the potential success of any changes. The success of integration policies is context-dependant, and pursuing forms of integration just for the sake of it is unlikely to result in sustainable cities or efficient working practices. Munich's Limux project may not succeed in other cities – the different needs and objectives of workers within other cities, the different IT architectures utilised by city authorities and the strong political and financial backing from city officials all contributed to the project's success in Munich. This may not be the case elsewhere and, even if it is pursued elsewhere, the results may be very different. Projects need to be analysed carefully in relation to their institutional surroundings – there is no one-size-fits-all approach to integration projects.

The third area of contribution relates to a theoretical contribution to the academic literature, and covers three strands of research. First, this thesis furthers the development of academic theories

surrounding socio-technical systems. It has been accepted since the 1980s through the work of Thomas Hughes that infrastructures are embedded into wider society, and socio-technical systems are both shaped by society and are society shaping. However, one aspect previously lacking in academic research is how the wider institutional structures of a given area can influence multiple socio-technical systems simultaneously: previous studies have mainly focused on individual socio-technical systems. While it is clear that many "infrastructure systems share patterns that can be exploited for learning and innovation" (Hansman et al. 2006: 6) there has been little research into how multiple infrastructures can be governed in specific locales. Instead, the majority of academic studies in infrastructure systems are often sector-specific and lack cross-cutting approaches that look beyond individual networks (Monstadt 2009). This project is an attempt to fill this gap, by researching the governance of multiple infrastructures and placing them in to a single conceptual framework, while bringing a specific urban angle to the analysis. The second theoretical contribution relates to bringing the system of systems approach to infrastructure management within the realm of the social sciences. The system of systems approach is dominated by the engineering disciplines and is primarily concerned with issues of compatibility surrounding new information and communication technologies. Very rarely do such studies consider the wider institutional impacts upon infrastructures, the political cultures that can shape their development, or the variations in policy that exist between cities and nations. This thesis argues that, while the system of systems literature is important, there are important institutional structures and context that impact upon their successful operation. Third, this thesis contributes to the literature on splintering urbanism. One argument of the splintering urbanism approach is that the progressive liberalization and privatization of national infrastructures has led to the fragmented governance of networks, with cities losing knowledge of their networks leading to difficulties in holistic planning. It is often overlooked that in some cities this splintering appears to be a desirable goal. In Seattle, I argued that the splintering of networks arises due to a form of *judicial splintering* that occurs as a result of the regulatory environment of Washington State. This splintering is intentional, not a byproduct of privatisation. Despite this, Seattle's main utilities remain publicly-owned by the city itself, and integration can still occur in operational forms.

While this thesis has made a number of important contributions, there are some limitations. First, the conceptual framework discussed above cannot be used to capture and describe the entirety of a city's views on infrastructure integration. There are a multitude of actors involved in the governance, management and operation of infrastructures, and while shared discourses may emerge it is inevitable that some people will have differing views on the viability of various forms of infrastructure integration. For example, while I have argued that actors within Sheffield aspire to integrate strategically, this does not prevent forms of infrastructure integration from occurring elsewhere (such as operational integration occurring through the need to manage the Streets Ahead PFI project) that may be covered in other areas of the framework. At no point during this research have I claimed that the labels I've attached to the three cities cover all forms of integration or splintering. Second, this project has utilised a purely qualitative methodology in examining forms of infrastructure integration and in examining the institutional structures of cities. By necessity, infrastructures involve a wide range of complex technologies (energy generators, fibre optic cables, overhead power lines, high speed rail lines etc.) that may best be understood through quantitative research methods. While I have argued that the governance and management of infrastructure is an important yet often overlooked aspect of infrastructure research, it may be beneficial to bring in

some aspects of quantitative methods. For example, what materials or technologies are available within each case study city? Does the institutional environment restrict the size or nature of underground pipelines or their maintenance? Do the specific voltage regulations in operation in the US, the UK, and Germany, influence the forms of integration that may emerge (for example in restricting the amount of distributed generation that can connect to the wider grid)? As a social scientist, these are questions beyond my expertise, however the variations in the possible answers could widen the scope of this project.

## 8.3 Avenues for Future Research

There are four main areas where I feel further research could be conducted to further develop the ideas generated within this thesis.

First, this thesis has looked in depth only at the three case study cities under consideration. As such, it may be subject to criticism that the conclusions are context-specific and not relevant to wider policy considerations (a criticism faced by any project using a case study methodology). It may be that other cities within the UK, US and Germany are experiencing similar pressures to their infrastructural networks but are reacting in different ways, drawing up solutions that may not have any relevance within Seattle, Munich or Germany. Further case study work is always welcome within qualitative research fields.

Second, the primary aim of this PhD project was to open the black box surrounding infrastructure integration. I argued that the term is a chaotic conception with no concrete definition and is often an abstract aspiration or a guiding principle. Throughout I have used comparisons to other terms prevalent within the modern infrastructure discourse – terms such as 'smart', 'sustainable' and 'resilient'. It may be fruitful for similar research to be conducted to understanding the meanings of those terms, to examine how the 'smart' concept has emerged and is being used within smart city debates, or to explore how desires to create sustainable and resilient cities are impacting upon the social and political life of residents.

Third, the institutional structures examined within this thesis have long historical roots. They were not created overnight. Instead, they have evolved over decades. While this thesis has examined how the current institutional context in the three cities can structure what forms of infrastructure integration may emerge, I have not fully explored the historical roots that have created these contexts. Future studies may find it fruitful to example the histories of infrastructure developments, examining how their development has evolved alongside their socio-political structuring environment. Moss' study of the Berlin electricity system (Moss 2014) is a good example of such a study, involving the examination of a city's history and the coevolution of the city's electricity network. In Seattle, it has been argued that the regulatory systems in Washington State have evolved to tackle the corruption associated with the growth of the railroads. Similar research examining how the histories of cities, their politics, their cultures and their socio-economic environment may prove fruitful in offering a sense of why infrastructures are governed in the way they are.

Fourth, this project has focused mainly on the 'elites' involved in infrastructural governance: policy makers, executive level managers, consultants etc. One often overlooked aspect of infrastructure research is the impacts on end users. How do forms of infrastructure integration affect the end users and consumers who ultimately depend on their successful operation? One key component of the MUSCo body of work is an emphasis on "end-user attitudes, beliefs, habits or routines, personal capabilities, and contextual factors" (Roelich et al. 2015: 42). This strand of research is beyond the scope of this PhD, but future work may examine how end users can become involved in infrastructure governance policies, or examine how institutional structures can allow or prevent consumers from facilitating their own forms of infrastructure integration.

Hopefully, this thesis has offered the reader a chance to understand the growing debates surrounding the integration of urban infrastructures and opened up potential debates for future urban infrastructure research. I hope to have demonstrated that there is no single definition that can be used across all urban environments, that the concept of integration is context-specific and dependent upon the institutional structuring environment in which urban actors find themselves. I also hope to have demonstrated that the term is not necessarily beneficial and that there are many directions for urban infrastructures to progress. As one interviewee from Seattle argued: "You never get everything. It's rare that you get to hit a home run" (interview, SPU executive).

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# APPENDIX A: PARTICIPANT INFORMATION SHEET

The University Of Sheffield.

EPSRC
Engineering and Physical Sciences Research Council

## Integrating Urban Infrastructures

## Information Sheet for Participants

### An Introduction

Infrastructures provide the bedrock of modern urban life. Today there is growing interest in the potential for resource and service efficiencies, as well as technical innovation, through various forms of 'infrastructural integration'. In Europe a new agenda of 'integration' raises the possibility to think differently about network provision with a growing recognition that future infrastructure needs to be smarter, more cost-efficient and more environmentally friendly.

This research project will examine the evolving context and the potential of infrastructural integration, exploring its meanings and implications in theory and practice. The research is funded by the UK Government's Engineering and Physical Sciences Research Council (EPSRC) which has called for new ways of thinking around the integration of utilities to offer major breakthroughs and identify opportunities for co-location and co-ordination of investment in large infrastructure assets. Although there is broad agreement about the importance (and the potential) of integration, precisely what this means in practice is unclear. Is it an abstract aspiration with little basis in reality? Or a guiding principle that could change how services are provided? This project will identify the possibilities for integration and seek to identify the capacities, opportunities and barriers that exist for technical systems to be integrated with each other and within wider society. The research will attempt to answer questions related to what infrastructures can be integrated and why, who decides, who benefits, and what governance frameworks are in place and need to be in place for integration to occur.

### Objectives

The research is a joint project between Sheffield University's Department of Town and Regional Planning and the Department of Civil Engineering. The project will attempt to uncover the complex processes taking place that allow or constrain infrastructural integration and to explore how long-term transitions are occurring.

The project has four overarching objectives:

1) To examine the possibilities for urban infrastructural integration.
2) To undertake detailed in-depth research on the organisational dimensions of urban infrastructural integration.
3) To examine progress on infrastructural integration and capacities for, and barriers to, integration in selected urban contexts.
4) To contribute to wider academic and policy debates about institutions, technologies and urban infrastructural futures.

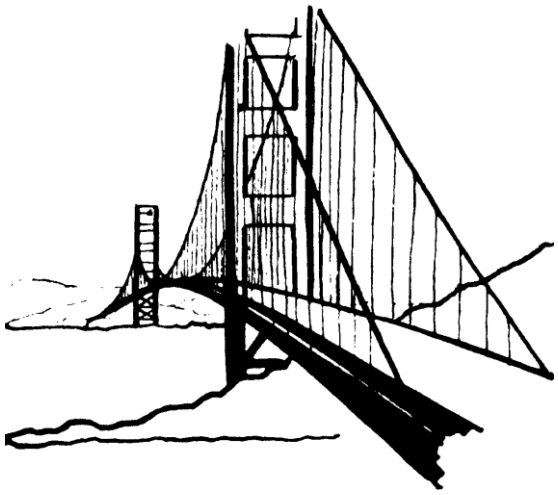
**Why Germany?**

On the face of it Germany appears more conducive to effective infrastructural integration than other major cities and could offer an example of 'best practice' infrastructural management: Several cities have very strong city-scale governance structures; Cities such as Munich have publicly-owned Stadtwerke organisations which may allow for close partnership working; and it is a country with a multitude of infrastructural efficiency, replacement and renewal projects underway. Germany appears to offer an excellent environment to facilitate the integration of infrastructure (whatever this may mean).

**The Interview**

Interviews will be carried out with those who have in-depth knowledge of Germany's infrastructure systems.

The interview will involve a discussion about infrastructures, their integration, management and operation. They will hopefully be interesting and engaging and involve a two-way conversation between the interviewer and the participant. The interview will be recorded by a Dictaphone. Written notes may also be taken



The audio will be stored on a password-protected laptop and will not be made available to the public. Transcripts will be made and notes will be taken, however these will only be made available to the researchers involved in this project.

By default, no names or personal data will be made available to the public. However participants will be able to choose their own level of anonymity, such as redacting their job descriptions or the names of organisations. A separate consent form will be provided. Measures will be taken to reduce the possibility for jigsaw identification. Transcripts of recordings can made be available on request.

The data will form the basis of a joint research project between the Department of Town and Regional Planning and the Department of Civil Engineering at Sheffield University. It may result in the publication of a number of academic papers.

# APPENDIX B: PARTICIPANT CONSENT FORM

The University Of Sheffield.

EPSRC

Engineering and Physical Sciences Research Council

Research Consent Form

Researcher: Anthony McLean (ajmclean1@sheffield.ac.uk)

I confirm that I have read and understand the information sheet for the study and I have had the opportunity to ask questions. I understand that my participation is voluntary and that I am free to withdraw at any time without giving a reason.

By default, no names or personal data will be made available to the public; however job titles and organisation details may be used in published material (for example, a city councillor or a senior executive at the city's Stadtwerke said…). Participants will however be able to choose their own level of anonymity, such as redacting job descriptions or the names of organisations.

The interviews will hopefully be interesting and thought-provoking. If, however, I feel uncomfortable in any way during the interview session, I have the right to decline to answer any question or to end the interview.

Participation involves being interviewed by a researcher from Sheffield University. Notes will be written during the interview, which will also be recorded electronically. A transcript of the interview will be available upon request.

I understand that the findings of the research may be published at a later date.

This research is subject to Sheffield University's requirements for ethics and data protection. The University Research Ethics Committee (UREC) has reviewed and approved the research proposal against the guidelines provided by the Engineering and Physical Sciences Research Council, the Natural Environment Research Council and the University's own guidelines interpreting the law on Data Protection.

Your signature below indicates that you have decided to participate voluntarily to this study and have read and understood the information provided. You will be given a copy of this form to keep.

Participant name (please print): _____

Signature: _____

Date: _____

Researcher name (please print): _____

Signature: _____

Date: _____

Note: If you have any difficulties with, or wish to voice concern about, any aspect of your participation in this study, please contact Dr Aidan While, Principal Ethics Contact, Department of Town and Regional Planning, The University of Sheffield (a.h.while@sheffield.ac.uk) or to the University Registrar and Secretary.