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The smart grid as commons: exploring alternatives to infrastructure financialisation

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The smart grid as commons: exploring alternatives to infrastructure financialisation

Abstract

This paper explores a tension between financialisation of electricity infrastructures and efforts to bring critical urban systems into common ownership. Focusing on the emerging landscape of electricity regulation and e-mobility in the United Kingdom (UK), it examines how electricity grid ownership has become financialised, and why the economic assumptions that enabled this financialisation are being called into question. New technologies, such as smart electricity meters and electric vehicles, provide cities with new tools to tackle poor air quality and greenhouse gas emissions. Electricity grids are key enabling infrastructures but the companies that run them do not get rewarded for improving air quality or tackling climate change. UK government regulation of electricity grids both enables financialisation and forecloses opportunities to manage the infrastructure for wider environmental and public benefit. Nonetheless, the addition of smart devices to this network - the 'smart grid' – opens up an opportunity for common ownership of the infrastructure. Transforming the smart grid into commons necessitates deep structural reform to the entire architecture of infrastructure regulation in the UK.

Keywords: Economic development, environment/sustainability, financialisation, governance, smart grid

Introduction

This paper draws together debates on the financialisation of infrastructure and the urban commons. Recent work on urban commons proposes bringing infrastructure into common (often localised) ownership, to pursue a balance of economic, social and environmental outcomes (Chatterton, 2016; Cumbers, 2015). In contrast, the drive to make infrastructure an investable 'asset class' (Inderst, 2010) shows how infrastructure can be 'financialised' so that cash revenues are prioritised over all other potential outcomes (O'Neil, 2016; Webb, 2014). This tension between the needs of global finance capital, on the one hand, and social and environmental outcomes on the other, poses the question whether commons based models of urban infrastructure ownership might be more compatible with urban sustainability. However, urban commons research has not gone far enough in challenging the economic assumptions that underpin financialised ownership models; nor has it

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3 justified *why* the management practices associated with commons might deliver a more balanced
4 set of outcomes. This paper will explore these underpinning economic rationales using the example
5 of electricity infrastructure, and the transition to electric vehicles in cities.
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9 We begin with an investigation of the urban commons, showing that urban infrastructures in
10 particular have been a focus of re-commoning. We propose commons approaches to infrastructure
11 need an explicit analysis of property rights. We then explore the ‘problem’ of infrastructure
12 economics and how it has underpinned the financialisation of electricity grids in the United Kingdom
13 (UK). We argue that financialisation forecloses pursuit of positive externalities. We then explain our
14 empirical focus on e-mobility in cities, before presenting case material which shows how an
15 infrastructure congestion problem can serve to either deepen financialised modes of provision, or
16 provide an economically grounded rationale for commons based management models.
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20 This empirical case addresses how air quality pressures are leading to car electrification in UK cities.
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22 Vehicle fleet electrification can improve air quality, but if the electricity grid cannot take the volume
23 of new load this implies, then transport electrification and by extension air quality management
24 suffer. However, electricity grids are owned by international finance capital, which has no reason to
25 prioritise investments that contribute to urban air quality outcomes. Is it just the financialised
26 ownership model that needs to change? Or, instead, the entire regulated revenue structure that
27 supports electricity grids across the world as well as the economic assumptions that underpin that
28 structure?
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41 **Defining the urban commons**

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43 There has been a recent resurgence of interest in ‘the commons’ in critical urban studies, a political
44 imaginary that potentially could allocate public goods and infrastructure resources more equitably
45 than [financialised] neoliberal urbanism (Chatterton, 2016; Enright and Rossi, 2018; Harvey, 2011).
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47 When exploring commons scholarship, it is important to see a spectrum between economic
48 interpretations and socio-political definitions. Economic interpretations develop from a critique of
49 the neoclassical economic literature on public goods; the concept of the commons is applied to
50 ecological common goods such as fisheries, forests, and clean air, where efficiencies and public
51 benefits can be derived from shared governance (Quinn *et al*, 2010). Collectively known as property
52 rights approaches, these studies have had a substantial influence on the natural resource
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3 management field (Ostrom, 2010). Increasingly however, the concept of the commons has been
4 applied to the production and distribution of resources in urban space, such as public transit
5 systems, infrastructure, and parks (Foster, 2011). This is where the definition begins to blur into
6 socio-political discourse on connected social struggles, and post-capitalist provision (Chatterton,
7 2016). For example, when referring to the 'commonwealth', Hardt and Negri (2009) include cultural
8 and socially mediated commons produced by cities. In this paper, we operate at the property rights
9 end of this spectrum and explore whether commons approaches to urban infrastructure can find
10 legitimacy even within a neo-classical framing.
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17 Using a commons/common pool resource approach to urban infrastructure, resists the reduction of
18 governance options to a binary between private and public expenditure. This binary pits neo-liberal
19 enclosure, privatisation and, ultimately, financialisation, against rigid state systems of provision.
20 Instead, the emphasis is on designing hybrid forms of collective provision around which community
21 and civic actors might mobilise. The normative aim of 'commoning' is to create localised institutions
22 of commodity or infrastructure governance, often through negotiation with the state hierarchy
23 (Harvey, 2011; Cumbers, 2015) and with a strong de-commodification theme (Bakker, 2007; Gerber
24 and Gerber, 2017).
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30 Civic commons research has investigated, amongst other forms of infrastructure, water (Bakker,
31 2007), public space (Radywyl and Biggs, 2013), broadband access (Rao and Parikh, 2003), and energy
32 systems (Becker *et al*, 2016; Wolsink, 2012). This research has examined the *commoning* of such
33 systems as a bottom-up response to the various enclosure, tolling, and financialisation processes
34 that characterise contemporary infrastructure governance (O'Brien and Pike, 2015; O'Neill, 2013).
35 Such contributions often present commoning, as a pathway towards multiple social and
36 environmental goals (Frischman, 2005; Hall *et al*, 2016). For example, Becker *et al* (2016) investigate
37 the social movements that have led to re-commoning of energy infrastructures in Germany (also Hall
38 *et al*, 2016; Moss *et al*, 2015). They highlight the role of urban social movements in re-configuring
39 infrastructure governance as well as the political drivers of institutional change. Many of these
40 studies, however, remain at the socio-political end of the spectrum, where researchers view
41 commoning as a "larger collective political experience, and as a way out of a life defined strictly by
42 the market and the state" (Huron, 2017 p.1063). Because the urban research on commons has
43 largely remained at the socio-political end of the spectrum, the economic assumptions at play are
44 rarely challenged on their own terms.
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3 Such terminologies are important, because they underpin the institutional design of urban
4 infrastructure systems (Mirrlees-Black, 2014). They are the basis on which economists tasked with
5 their governance make decisions (Earle *et al*, 2016). Assumptions about the economic
6 characteristics of individual infrastructures and their property rights shape how they have become
7 financialised, and the institutions that have been built around them to enable that financialisation
8 (O'Neil, 2016; Helm, 2009; Vatn, 2007).
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14 Reasoning within neo-classical terminology has proved extremely fruitful in the natural resource
15 management field, where property rights scholars have demonstrated that close attention to
16 institutional design affects how agents behave towards the finite resources in question (Ostrom,
17 2006; Bowells, 1998); the assumptions we make about individuals, affects their willingness to co-
18 operate (Vatn, 2007). Broadly, it shows that marketised incentives lead to individual utility
19 maximisation behaviour, while communal rule systems lead to enhanced co-operation.
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24 If the same is true for urban infrastructure resources, then financialised ownership structures, whose
25 rationale is generally grounded in neoclassical utility-maximising economic theory (O'Neil, 2016;
26 Arnspenger and Varoufakis, 2006), would design rule systems that reproduce and re-enforce market
27 based incentives. If different assumptions were made about the resource in question and different
28 theories of individual behaviour applied, then different behaviours might be rewarded, reinforced
29 and produced. This might include commons based models; but if this commoning is to be seen as an
30 alternative to privatisation and financialisation, it should have some economic as well as socially
31 normative rationale. Put simply, if we assume that infrastructure is more than a simple commodity
32 and design systems of ownership and governance that reflect that change, we might achieve
33 different outcomes.
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42 **Property rights and infrastructure economics**

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45 In identifying the economic rationale underpinning infrastructure financialisation, it is helpful to
46 revisit some key assumptions within neo-classical economics. Samuelson (1954) divided goods into
47 two types: private and public. Pure private goods are simultaneously rival (if individual A is driving a
48 car, individual B cannot drive that car) and excludable (if individual B drives individual A's car without
49 permission they can be excluded from doing so). Public goods, on the other hand, are non-rival and
50 non-excludable (Individuals A and B can both benefit from national defence without their
51 consumption of sovereign safety being reduced, and as sovereign citizens cannot be excluded from
52 doing so). This division allowed neo-classical economics to estimate the optimal level of public
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3 expenditure, assuming that private goods exchanged in free markets always discover 'optimal'
4 prices. Public goods are services where markets do not exist or are impossible to create, and so need
5 to be supported by taxation.
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9 Infrastructure is often characterised as a public good (Helm, 2013), but the dichotomy of pure
10 private and public goods does not bear closer scrutiny: individuals and institutions can organise to
11 consume small scale non-rival goods which, in turn, can be made excludable. Buchanan (1965)
12 dubbed these 'club goods', a pertinent example being a 'city car club' where the club membership
13 shares a pool of vehicles that non-members can be excluded from. Buchanan proposed the
14 characterisation of a good depends not on its innate qualities, but on the social rule systems
15 (institutions) that are created to govern it.
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21 V. and E. Ostrom (1977) identified a fourth type of good known as a 'common-pool resource' and
22 refined the terminology. Rivalry became 'subtractability' because the utility of goods is reduced at
23 different rates depending on use intensity or congestion (also Brown *et al*, 2014). Excludability was
24 also conceived as a matter of degree. Common pool resources like a fishery or agricultural water
25 table have complex subtractability and excludability characteristics. They can be overharvested and
26 access may be based on a basket of historical rights claims. Finally, 'club goods' became 'toll goods'
27 as they can be provided collectively by municipal/local councils as well as private clubs.
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34 The category of 'common-pool resource' (see, e.g., Ostrom, 2010, p. 645) has had a huge impact on
35 the practise and study of natural resource management problems, highlighting the power of
36 communal ownership and co-produced rule systems particularly for small-medium sized natural
37 resource systems. A key ideological division emerged between those who followed Ostrom in
38 arguing that polycentric governance, co-operation and institution building could effectively manage
39 common-pool resources, and subscribers to Hardin's (1968) 'Tragedy of the Commons' argument.
40 Hardin used a common grazed pasture example, where more and more commoners add more and
41 more grazing animals until the pasture is exhausted. This Hardin argued, meant common-pool
42 resources are best protected when higher level authorities either regulate the resource, or assign
43 and enforce private property rights to prevent over exploitation (Quinn *et al*, 2010). In an
44 assessment of the respective merits of the two arguments, Coase (1960) argued that the private
45 property approach was more efficient at managing externalities and spillover effects.
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3 Here we are directly concerned with the division between the private property approach to
4 managing externalities proposed by Coase, and the polycentric commons approaches advocated by
5 Ostrom. Ostrom argued that common ownership of the resource in question, along with a series of
6 institutional design principles, can find effective ways of both controlling over-exploitation and
7 managing externalities (Ostrom, 2010; 2010a). The question is, whether the same is true for urban
8 infrastructure systems as for natural resources?
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14 In contrast to natural resources, infrastructure systems have received little attention from property
15 rights scholars. In part this is due to three problematic characteristics of infrastructure which make
16 analysing it through a neo-classical lens extremely problematic (Brown *et al*, 2014), and often attract
17 analysis to the role of the state in provision. These three problems are explored below using the
18 operating example of the UK electricity system and its associated infrastructure.
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25 **Three problematic characteristics of infrastructure: the case of UK electricity systems**

26 The first problem is infrastructure's public good characteristics, i.e., degrees of non-excludability and
27 non-rivalry, which necessitate different degrees of state intervention as private levels of provision
28 are likely to be below optimum (Helm, 2010; Little, 2005). The second problematic characteristic is
29 the natural monopoly tendency of infrastructure (Helm, 2010; 2013). Natural monopolies arise
30 where there are large sunk costs and increasing economies of scale (Brown *et al*, 2014). Such scale
31 economies lead to few or single providers which have absolute power over pricing access to
32 essential services, and therefore the state steps in to regulate these prices (Helm, 2013). Further
33 problems arise in ensuring these prices cover investment, deepening the state's role as a contract
34 provider (Helm 2010).
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42 The third and final characteristic of infrastructure is the externality problem. This problem arises
43 when both positive and negative spillovers exist, but are difficult to price directly into infrastructure
44 provision. For example, it is difficult to charge a firm for positive externalities such as labour
45 productivity gains from healthy workers arising from improved sewerage provision, or to value the
46 climate externalities of a new road investment without carbon pricing. However, since net
47 infrastructure spillovers are generally accepted to be positive (Esfahani, and Ramírez, 2003), it is
48 beholden upon the state to determine the optimal level of provision by accounting for these
49 externalities (Helm, 2010; Brown *et al*, 2014).
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3 The first two problems can be solved by the direct state provision of infrastructure funded through
4 taxation, or by allowing private provision with some form of consumer protection from monopoly
5 pricing (Helm, 2009). The question of whether and how privatisation should occur for network (i.e.,
6 urban pipe and cable) infrastructures rests on whether a legitimate institutional regime can be
7 constructed to exclude non-paying users, but cap user charges at an acceptable level (Helm, 2009;
8 Torrance, 2008).
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14 The problem of how to manage monopoly infrastructure pricing under private provision was salient
15 during the liberalisation and unbundling of the UK electricity system (Meek, 2014). For electricity this
16 meant the separation of the system into competitive markets for generation (wholesale) and supply
17 (retail), and regulated monopolies for transmission and distribution networks. This resulted in a
18 liberalised and unbundled market structure.
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23 Assessing the economic characteristics of each part of the system in turn allowed consideration of
24 which elements comprised which type of economic good. Thus generation and supply were classed
25 as private good commodities (Rutledge and Wright, 2011; Kotchen and Moore, 2007). A kWh of
26 electricity is both excludable, in that it can be metered, and rivalrous, in that one's neighbour cannot
27 consume the same energy and more generation must be added to the system to satisfy their
28 demand. This led to the creation of wholesale markets for generation and retail markets for supply
29 (Rutledge and Wright 2011; Lockwood *et al*, 2016). The enabling infrastructure, i.e. the high voltage
30 transmission system and low voltage distribution networks were cast as a toll good, in that they are
31 easy to exclude users from, and the marginal cost of extra use (rivalry/subtractability) was low. This
32 process of parcelling up the electricity system for privatisation required an institutional regime
33 which had to manage the three 'problems' of infrastructure economics outlined above.
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42 The first problem of public good characteristics (excludability) was already dealt with by metering
43 and billing. However, the second, (the control of monopoly pricing) resulted in the regulation of
44 what grid companies could charge to consumers. This price control was based on the RPI-X formula,
45 which allowed revenues of grid companies to rise with the Retail Prices Index (RPI, similar to
46 consumer prices index) minus 'X' an efficiency metric agreed between the networks and the
47 regulator. Almost all grid companies' revenues are based on this formula. This means the 'balance of
48 risk and reward for regulated companies is determined almost entirely by the nature of the RPI-X
49 regulatory regime, and those companies react to that regime rather than to market opportunities'
50 (Lockwood 2016, p. 112). Energy sector research criticises the RPI-X model for a lack of innovation
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3 incentive (Müller, 2011; Bolton and Foxon, 2011). While the new (2014) UK regulatory settlement
4 known as RIIO (Revenue=Incentives+Innovation+Outputs) endeavours to better reward innovation,
5 another underpinning institution of network regulation, the regulated asset base, or RAB model,
6 remains relatively unchanged (Wild, 2017) and certainly unchallenged by an urban studies
7 community.
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12 The RAB model is a state guarantee that ensures networks will be able to repay the finance they
13 need to continue their activities (Stern, 2014). It allows the cost of servicing investments to be
14 passed onto customers, ensuring the electricity bill payer carries the risk of new investment by the
15 network company (Stern, 2014). This RPI-X with RAB model has enabled, incentivised, and stands as
16 a global 'example' for the privatisation and financialisation not only of electricity networks but also
17 of gas, rail, airports, communications and water infrastructures (Stanley, 2011; Mirrlees-Black, 2014).
18 This institutional regime makes the investment of private capital in infrastructure a relatively low risk
19 proposition. It has led the ownership of UK grid infrastructure to include transnational firms, such as
20 JP Morgan, Cheung Kong Group, and Berkshire Hathaway. The continuing financialisation of these
21 assets is demonstrated by Macquarie's recent acquisition of a 61% stake in a gas distribution grid
22 serving 11m homes in the UK (Dummett and Salvaterra, 2016). Helm, (2009) argues that the RAB
23 model incentivises financialisation by rewarding companies for debt mortgaging of infrastructures
24 over operational efficiencies; meaning the gains from financial engineering can easily outweigh
25 those from better network management (Helm, 2009;). Wild (2017) demonstrates that small (i.e.
26 0.1%) variations in regulatory assumptions over debt and equity costs can lead to network
27 profits/losses of tens of millions irrespective of the actual performance of the network business.
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39 This institutional regime of the RPI-X and RAB model imperfectly deals with the first two problems of
40 infrastructure economics, but does almost nothing to reward network companies for the multiple
41 externalities which accrue to different stakeholders in different systems. These regulated revenues
42 do not reward the pursuit of positive socio-environmental or economic externalities that benefit
43 cities (Hall and Foxon, 2014). These positive externalities may outweigh the financial benefits that
44 accrue to the infrastructure owner, but since the RPI-X and RAB model do not capture them,
45 infrastructure programmes that would otherwise generate net gains in terms of public health,
46 environmental protection etc., are marginalised in favour of maximising returns to finance capital
47 (O'Neil, 2016; Webb, 2014).
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53 The potential of smart grid investments to enable these positive externalities has not escaped the
54 attention of urban activists, who in several cases have 're-communalised' (Fei and Reinhart, 2014)
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3 grid infrastructures by taking them into municipal or civic ownership. They have done so to both
4 harvest the traditional revenues available, *and* pursue the positive externalities that smart grid
5 investments can confer (Becker *et al*, 2016). However, taking grids into communal ownership may
6 allow some re-direction of earned revenues, but it does not change the governing institutions of the
7 infrastructure i.e. the RPI-X and RAB model. Re-communalising means bringing into communal
8 (usually municipal or co-operative) ownership, whereas re-commoning would mean a partial de-
9 commodification. Any *re-communalised* grid may be forced into the same financialised calculus that
10 drives corporate grid managers resulting from an unchanged institutional regime.

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12 Although the importance of urban politics of smart grids have been critically examined (Bulkeley, et
13 al 2016, Zhou and Matisoff, 2016), urban and infrastructure studies have yet to question whether
14 the underlying institutional resource regime, i.e., the RPI-X/RIIO/RAB toolbox, is fit to secure
15 multiple positive externalities enabled by smart grid investments. Nor have commons scholars spent
16 sufficient time coming to terms with the property rights implication of these institutional regimes.

17
18 Kunneke and Finger (2009), do explore the property rights assumptions that underpin urban
19 infrastructure governance. They point to liberalisation as a process of institutional fragmentation,
20 competing interests, and mixed incentives; giving rise to complex co-ordination issues. They argue
21 this is more akin to common-pool resource governance than toll good operation. Künneke and
22 Finger (2009 p.5) further argue that electricity grids are better conceived as common pool resources
23 because:

- 24 1. Excludability of access maybe technically possible but politically unfeasible.
- 25 2. Once access is gained it may be difficult to determine how users appropriate services.
- 26 3. *Access is open (after a fee)* yet these are services from which each individual user takes
27 benefit at the expense of others; i.e., there is rivalry in the consumption.

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29 In summary, the institutional regime built around electricity distribution infrastructures in the UK
30 stands as an international 'exemplar' of how to financialise network infrastructures. This regime is
31 legitimated by property rights assumptions that cast the grid as a toll good, and create regulated
32 charging structures to prevent monopoly pricing. However, it has not solved the problem of multiple
33 externalities, such as economic development, carbon control, and air quality management, which
34 are conferred by smart grids on cities. The natural resource management community has often
35 found common property regimes are better able to manage resources for complex outcomes. Given
36 the multiple positive externalities associated with smart grid development in cities (Hall and Foxon,
37 2014; Webb, 2014), the research question is: Would the positive externalities of smart grid

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3 infrastructure benefit from a property rights settlement that assumed they constituted a common-
4 pool resource as opposed to a toll good?
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8 **Methods**

9 A three phase methodology was used. Phase 1 consisted of case study selection. We selected urban
10 e-mobility (the transition to electric car use) as a theory-confirming case (Yin, 2011) for two reasons.
11 Firstly, there is evidence suggesting the presence of high positive externalities/spillover effects
12 associated with e-mobility at the urban scale in respect of air quality, economic development and
13 carbon control (Hall *et al*, 2017). Because UK cities do not control energy infrastructures but do
14 capture spillover benefits of e-mobility, one might expect cities to be increasingly interested in
15 electricity grid governance. Secondly, the capture and maximisation of spillover benefits often enrolls
16 multiple parties in negotiation and re-negotiation of boundaries, access and resource use behaviour
17 (Ostrom, 2010). Thus the need of e-mobility transitions to enrol smart grids, drivers, city
18 governments and network companies manifestly demonstrates a 'complex co-ordination issue'
19 which Kunneke and Finger (2009) claim as a key characteristic of common pool resource dilemmas.
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28 Phase 2 involved 22 semi-structured interviews with 26 individuals. Participants were selected with
29 direct experience of electric vehicle infrastructure management in the UK. Questions were formed
30 around the barriers and enablers for increased electric vehicle penetration in cities with a specific
31 focus on infrastructure governance. The sample comprised: 4 interviewees from city governments, 3
32 vehicle manufacturers, 2 auto industry and public partnerships, 3 charge infrastructure providers, 3
33 energy utilities, 2 academics, 2 energy system regulators, 2 fleet managers, and 1 government
34 department.
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41 In phase 3, two expert focus groups were undertaken, designed to understand the co-ordination
42 issues and trade-offs involved in different methods of managing e-mobility transitions and
43 infrastructure stress. Focus group #1 comprised: 1 energy supplier, 2 city managers, 1 government
44 sponsored innovation incubator member, 3 academics, 1 charge point provider and 1 infrastructure
45 operator. Focus group #2 comprised: 2 officers of the energy regulator, 3 vehicle manufacturers, 3
46 academics, 2 charge point providers, 2 energy suppliers, 2 fleet managers, 1 government
47 department, 2 independent energy systems experts, 1 government sponsored innovation incubator
48 member, and 1 auto industry body. The remaining sections report the initial findings of this
49 research.
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The role of cities in e-mobility infrastructures

Until recently a common Cost Benefit Analysis has been used to prioritise transport infrastructure spending in UK cities which assessed economic, environmental and social impacts of new schemes (DfT, 2016). Using cost-benefit approaches, the state can comparatively assess competing infrastructure schemes for the ratio of capital costs against other positive and negative externalities. However, since more infrastructure spending power has been devolved to city-regions in the UK (O'Brien and Pike, 2015a), infrastructure assessment has become much more focussed on a single positive externality (spillover effect), that of economic development, as opposed to an assessment of economic, environmental, and social benefits (Mullen and Marsden, 2015). The common cost-benefit framework suitable to public good assessment has been replaced by a hybrid economic development assessment. Following this, new air quality management responsibility and road user charging powers have also been devolved (House of Commons, 2016). In short there has been a series of changes to transport infrastructure governance in cities. These changes have emphasised aggregate private gain over public good gains by focussing on economic development spillovers from transport infrastructure schemes. This replaces the cost benefit approach of travel time benefits weighed against environmental and social impacts.

Until recently those responsible for sustainable transport spending did not have to consider energy infrastructures. However, recent research shows that poor air quality in towns and cities in the UK contributes to over 40,000 premature deaths every year (Royal College of Physicians, 2016). In July 2017 the UK Government published its Clean Air Strategy (DfT & Defra, 2017) as a response to a legal battle over urban air quality. Poor air quality, particularly nitrogen dioxide levels from diesel vehicles in towns, mean that legal limits in many UK towns and cities are regularly exceeded (Boffey, 2016). This 'public health emergency' (House of Commons, 2016) led campaigners to push for concerted government action that has culminated in government placing further responsibilities on cities to find solutions. One proposal is the banning of sales of all new pure petrol/diesel cars by 2040. This demonstrates that air-quality concerns are the primary regulatory drivers for the electrification of passenger cars.

Supporting electric mobility in UK cities has thus far been limited to parking and charging provision; urban transport bodies providing public charge points at strategic locations. This provision has become dependent on grants from central government, leading to uneven coverage across the UK. Cities have been restricted in how they support electrification because parking and charging is the only piece of enabling infrastructure they have control over:

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3 *"...at the moment, we are tinkering around the margins, I mean, great, take the Elland Road [Leeds]*
4 *Park and Ride, we've got a few charging points there, which is great. If actually every single car on*
5 *that car park wanted to charge, it wouldn't be able to happen would it? Because the grid wouldn't*
6 *support it and then that... so, at what point do we start to really worry about that?"*
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10 (Source: City Government Officer, 2016)

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13 *"We kind of know what we need, what needs to happen but it's just a question often of getting*
14 *collective interested parties pointing in the right direction at the right time. Because what's been*
15 *done in the urban environment so far has been pretty much hopeless"*
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18
19 (Source: Energy Supplier, 2016)

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21 This "hopelessness" is in part due to the fact that, after privatisation and subsequent financialisation
22 of the UK electricity system, cities have almost no influence over the single most important
23 infrastructure for enabling e-mobility, the electricity distribution grid.
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29 **Energy systems in urban e-mobility**

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31 *"So imagine going into any council in the UK and say right tomorrow you are not going to control any*
32 *of your roads, at all, and what we are going to do is we are going to give it to a private sector*
33 *company and then they are going to run your roads without any regard to anything you have*
34 *actually got to say, anything you have got to strategically plan where you are going to build your*
35 *developments, they are going to charge all your road users irrespective of anything you have got to*
36 *say, to travel across those roads. And you have got no ability to either control that pricing model or*
37 *even have a say at the table with regards to development [...] People would just look at you as if you*
38 *were just absolutely bonkers. As a model to drive or even control your strategic assets... you can see*
39 *why it wouldn't work, and that's effectively what we have got in the distribution network"*
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42
43 (Source: City Government Officer, 2014)

44
45 UK cities have no statutory involvement in the governance of electricity infrastructures. Most
46 electricity systems are centralised, built on a model of high capacity plant, connected to
47 infrastructure networks which step down voltages to useable levels for homes and businesses.
48 Electricity, unlike gas, oil products, or solid fuels, cannot be stored. Electricity systems have
49 therefore been built so supply matches demand at any period and system frequency remains within
50 design limits. The addition of vehicle batteries to this system does not change these parameters, it
51 either places more stresses upon them, or offers more flexible ways of fulfilling them, depending on
52 how the vehicle charge cycle is managed. If the charge cycle goes unmanaged this can create
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3 problems of 'grid constraint' a congestion of the infrastructure due to the load electric vehicles (EVs)
4 place on these distribution networks:
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8 *"...Well the challenge that we've had is that it is very difficult to supply sufficient power for a*
9 *significant number of vehicles at any one time. In terms our own fleet we have been kind of restricted*
10 *on most sites two or three electric vehicles, sometimes up to five. But where we've got opportunities*
11 *in terms of suitability of fleet transition to have say 10, 12 even 20 electric vans operating from one*
12 *site, we've not been able to do that because we haven't got sufficient power [grid capacity] at those*
13 *sites"*
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16
17 (Source: City Government Officer, 2016)
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19 *So for home charging, you know. Clearly there's a number of issues that come out. First it's scale.*
20 *You'll get a clustering effect of vehicles in certain neighbourhoods and networks. A sort of panel*
21 *effect, when one house gets one, another house wants to get one too. So you've got a local problem*
22 *in terms of infrastructure; can that local infrastructure manage the demand at the same time?*
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25 (Source: City Government Officer [different to above] 2016)
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28 It is at this point of congestion where the economic assumptions that regard distribution grids as a
29 toll good break down, as the marginal cost of extra consumption by consumers with EVs increases
30 exponentially as the resource becomes congested, In natural resource terms, distribution grids are
31 being 'overharvested'.
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36 *"... the effect of the EVs on the grid is, in fact, not only quite high; it's actually going to make things*
37 *worse and there isn't any mechanism to stop that from happening."*
38

39 (Source: Energy Supplier, 2016)
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42 The low subtractability/rivalry characteristic of a toll good is no longer fulfilled. If the property right
43 characteristics are re-considered, several strategies may present themselves which could prevent
44 'overharvesting' of the infrastructure.
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48 In a traditional 'dumb' distribution grid, once consumers have secured access to the network it is
49 impossible to determine whether their consumption contributed to peak levels of congestion, as no
50 individualised time of use data was available. Because of this, the high marginal costs of peak
51 consumption are borne by all users. However, the roll-out of smart grids, comprising smart
52 electricity meters, new network monitoring technology, and new demand side management
53 techniques mean that new opportunities *are* emerging to monitor user demand and manage peak
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3 use periods. These new technological enablers fall into two categories, demand side participation
4 and demand side management.
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7 Demand side participation involves a behaviour change by a system user to shift demand to a
8 different time of day. Demand shifting has three main benefits: 1) to help the system operator
9 (National Grid) to keep the system within engineering specifications, 2) to use energy when it is
10 cheapest (usually in periods of low demand or high renewable generation), or 3) when any extra
11 demand would overload the low voltage infrastructure carrying the electricity. Demand response
12 can benefit different parties in the energy system with different incentive structures that do not
13 always align.
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20 *“...For example, if you are contracting services with the National Grid you need to pay attention to*
21 *what kind of services you are contracting with a DNO¹ because you can't offer the same service or*
22 *the same resources aggregated to both of them.”*
23

24 (Source: Energy infrastructure provider, 2016)
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28 This is a further characteristic that suggests electricity grids are common pool resources; many
29 parties make different claims on each other at different times which lead to complex co-ordination
30 issues, as suggested by Kunneke and Finger (2009).
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34 If distribution grids were understood as a common pool resource problem there would need to be
35 monitoring infrastructure in place to police extraction (Ostrom, 1990). This has not been possible
36 until recently; traditional meters in homes and small commercial premises only measure aggregate
37 use, not when that use occurs. This means that most domestic and small commercial consumers are
38 settled on a profile, and the characteristics of their resource extraction cannot be monitored. Smart
39 metering changes this, as it allows consumers to be half hourly settled, i.e., they can be billed for
40 exactly what they use and when they use it:
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47 *“So with the half hourly settlement, if you have a smart meter we would be able to charge, put your*
48 *unit rate on a half hourly basis. So you could do that, but actually the costs that will be incurred in*
49 *terms of the network costs and the actual wholesale costs of that. So the network and wholesale cost*
50 *we would still being billed as if they were profile customer. **Whereas with elective half hourly***
51 ***settlement, and in future mandated half hourly settlement, the charges will start to become more***
52 ***reflective.”***
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56 ¹ Distribution Network Operator, the company responsible for the local, low voltage grid.
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3 (Source: Energy supplier 2016; emphasis added)
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6 What is being described above is the need for consumers to have a smart meter *and* 'elect' to
7 choose half hourly billing. Being more 'reflective' refers to cost reflective pricing. The problem with
8 cost reflective pricing for an EV consumer, is that while the distribution network companies *could*
9 remunerate electric vehicle consumers for charging during periods of low network use (i.e. during
10 the night) it is the supplier/retailer who has control over the billing process. With different
11 households having different suppliers and switching at increasing rates, it is extremely difficult to
12 construct a remuneration regime for consumers to respond to, if the goal is to better utilise the grid
13 resource (Distribution Network Operator officer focus group responses). An additional disincentive is
14 the monetary value of flexibility to single consumers:
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21 *"It's very difficult to see why the customer would be incentivised to do that [load shift] unless there*
22 *was a significant financial upside for them to do that. Which there wouldn't because power with*
23 *electricity is cheap and unless there was some kind of model that every time you flatten your peak at*
24 *breakfast time, we'll give you fifty quid..."*
25

26 (Source: Energy supplier, 2016)
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29 This suggests that, unless the financial rewards/penalties for good/poor demand side participation
30 were substantially higher than the marginal cost of use, it is unlikely individual EV consumers would
31 find behaviour change worthwhile. They could co-operate with the grid company without reward,
32 but as Vatn (2007), Ostrom (2006), and various experimental and ethnographic studies demonstrate
33 (i.e. Ross and Ward, 1996), the marketised relationship with the private corporate provider does not
34 motivate selfless co-operation.
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39 This is why we are interested in commons approaches to infrastructure use. Monetary rewards to
40 rational individuals are small and complex to administer. Another approach is to remove the price
41 incentive altogether and operate grid management on a co-operative basis. This is technically
42 possible using remote interruption of vehicle charging during peak times to protect the grid from
43 overload.
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50 This changes the property rights relations with the infrastructure provider from a simple toll fee for
51 access, to a managed regime requiring consent and co-operation. However, moving from a simple
52 fee for access model to a model requiring more user engagement is difficult:
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3 *"I'm aware of the impact on the grid, your average consumer won't care and couldn't care less. Why*
4 *should they? So there's a potential ticking time bomb with that which needs to be solved. And one*
5 *way to solve it is [...] adjust the energy flow. Either reduce it or even make it bi-directional so it can*
6 *supply energy at given times, which, will consumers be happy with? Given the large amount of*
7 *money they paid for the very expensive battery in the car, and actually very little financial return for*
8 *the energy...?"*
9

10 (Source: City Government Officer, 2016)
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13 The problem with hardwired demand side management (DSM) is that consumers have no incentive
14 to allow for flexibility if it is not remunerated through the bill unless it is part of a wider consensual
15 rule system. A consistent theme in smart grid innovation trials has been the need to closely engage
16 consumers and provide detailed information on why the network is in need of closer management
17 (Fisher *et al*, 2015; Frontier Economics, 2015). This is because the infrastructure constraint issue has
18 an extremely stubborn geography:
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24 *"It's not an issue of total demand [...], it's a question of managing peaks, but it's worse than that. It's*
25 *also about managing street by street, house by house..."*
26

27 (Source: Vehicle Manufacturer, 2016)
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30 The need to enrol communities on such a tight geography, and provide channels of communication
31 which either drive behaviour change or legitimise direct intervention in the charge cycle, may be
32 successful in small, well-funded trials, but they are not compatible with the current relationship of
33 millions of householders with their distribution network operator. This need for personal
34 communication, localised co-operation, and behaviour change in favour of resource conservation
35 represents many of the characteristics documented by common pool natural resource management
36 scholarship (Vatn, 2007; Künneke and Finger, 2009; Quinn, 2010).
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43 **Discussion and conclusion**

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46 This research explores a tension between financialisation of electricity infrastructures and efforts to
47 bring critical urban systems into common ownership, using the UK electricity grid system as an
48 exemplar. The institutions governing the distribution networks, principally the RPI-X and the RAB
49 model, were designed for the private provision of a toll good, beyond the reach of city governments.
50 This model is unable to account for the positive externalities of e-mobility in cities, or enrol multiple
51 resource users in new governance structures. This is because under a RAB model, with its tendency
52 towards financialised ownership, the beneficial owners of the network do not capture positive
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3 externalities that include air quality benefits [principal in this case], greenhouse gas mitigation,
4 economic development effects and the ability to better optimise wider decentralised energy systems
5 of cities (Webb, 2014).
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9 This research demonstrates that new technologies, principally smart metering and demand response
10 applications, offer new opportunities to enrol customers in the management of the grid resource.
11 Given that grid constraints manifest on a 'street by street' basis, the geographies and communities
12 of electricity distribution become much more important in the future management of the resource.
13 The need to co-ordinate these assets to address the 'public health emergency' of air pollution in UK
14 cities, and a wider drive to strategically manage energy assets across cities, to maximise positive
15 externalities, is drawing municipalities and communities more concretely into the issues of grid
16 management.
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23 There has been recent interest amongst UK local authorities in taking distribution grid assets into
24 municipal control to deal with some of the issues identified above. For example, Gateshead City
25 Council has purchased part of the distribution network from the incumbent grid company to support
26 a new combined heat and power smart energy centre (Gateshead City Council, 2016). This is a small
27 example of re-municipalisation of elements of the UK distribution network, which is becoming more
28 attractive to UK cities as grid access and management becomes the major barrier to distributed
29 energy system development (Core Cities, 2013). In Germany and the US there have been wholesale
30 re-municipalisations of distribution grids (Fei and Rinehart, 2014). Such efforts at re-communalising
31 represent what some in the urban commons community would see as a positive step towards de-
32 commodifying critical infrastructure. However, taking a property rights approach demonstrates that
33 beneficial ownership of the infrastructure resource by a municipality does not make for
34 infrastructure as commons. What matters is how inclined a new owner is to manage the
35 infrastructure resource as an urban planning tool to maximise positive externalities (O'Neill, 2016),
36 and thus move away from a pure toll good relationship by taking a more pluralistic approach to
37 value.
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48 We asked: would the positive externalities of smart grid infrastructure benefit from a property rights
49 settlement that assumed they constituted a common-pool resource as opposed to a toll good?
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53 At this stage there appear to be two pathways that the institutional governance of smart grid
54 transitions can take. These two pathways are to push the resource towards further enclosure and
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3 cost-reflective user charging, thus moving toward a private/toll good hybrid model, and deepening
4 the monetisation of behaviour change and the calculus of financialisation. The second pathway
5 involves using these technologies to manage the grid as a toll/common-pool hybrid by enrolling new
6 actors and new governance structures to manage the resource to maximise positive externalities.
7 Doing so implies complex co-ordination and co-operation issues that are more akin to common-pool
8 resource management problems. The latter option would require an entirely new institutional
9 regime to replace RPI-X and the RAB model with something much more compatible with common
10 pool resource design principles (Ostrom, 1990; 2010).
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17 Smart meters with half hourly settlement, consumer participation, and cost reflective pricing could
18 very well enable grid operators to charge the marginal cost of provision to those who use the grid at
19 periods of congestion. This would fit very well with a neo-classical rational economic actor approach,
20 which would stipulate the closer to a private good the resource can become the more efficiently it
21 can be managed through a price signal (Coase, 1960). Cost reflective pricing of a toll good is much
22 more compatible with the existing financialised ownership structure of many distribution network
23 operator companies. However, focus group participants in this research highlighted ethical and
24 distributional concerns over the impact of this type of pricing on vulnerable consumers who may not
25 have the ability to switch load and may get penalised by high peak charges. This echoes Kunneke and
26 Finger's (2009) point that while it may be technically possible to move to a more private logic and
27 marginal cost approach it may be politically unfeasible due to universal service concerns.
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36 The second pathway, managing the grid as a common-pool resource, is arguably more complex in
37 that it involves finding a mix of institutional measures and consensual rule systems which prevent
38 over harvesting of the resource by deploying demand-side management measures and incentivising
39 behaviour change with little or no market exchange of value. This would mean constructing an
40 entirely new governance regime that enrolled consumers in new relationships with the
41 infrastructure provider through behavioural change *and* consensual rule systems. It is unclear
42 whether the re-municipalised and communalised ownership structures emerging through the
43 various examples of commoning seen across multiple OECD nations (Fei and Reinehart, 2014;
44 Becker, *et al* 2016) are more compatible with this approach if the underlying institutional regime
45 remains unchanged. However, it is clear that accounting for the multiple spillover benefits of smart
46 grids in cities, not least in enabling e-mobility, does require a re-evaluation of property rights claims
47 within urban infrastructure provision. This re-evaluation would threaten the existing regime, the
48 sunk costs of investors, and the long term stability of the invested capital that feels secure under the
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3 RAB model. This cannot be taken lightly as it would likely increase the cost of capital, and therefore
4 increase energy bills across the nation, if a regulator were even seen to be considering such a radical
5 change to the system (Stern, 2013). It is this weight of incumbent interests, committed over such
6 long timescales, that any more spatially compatible proposal for grid management would have to
7 contend with.
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21
22
23
24

25 **References**

26
27
28
29
30 Arnsperger, C. and Varoufakis, Y., 2006. What Is Neoclassical Economics? The three axioms
31 responsible for its theoretical oeuvre, practical irrelevance and, thus, discursive power.
32
33
34 *Panoeconomicus*, 53(1), pp.5-18.
35
36
37
38

39
40 Bakker, K., 2007. The “commons” versus the “commodity”: Alter-globalization, anti-privatization and
41 the human right to water in the global south. *Antipode*, 39(3), pp.430-455.
42
43
44
45

46
47 Becker, S., Naumann, M. and Moss, T., 2016. Between coproduction and commons: understanding
48 initiatives to reclaim urban energy provision in Berlin and Hamburg. *Urban Research & Practice*,
49 pp.1-23.
50
51
52
53
54
55
56
57
58
59
60

1
2
3 Boffey, D (2016) Four in 10 UK councils exceed air pollution limits, figures show, *The Guardian*, 22nd
4
5 October 2016. Accessed online at [https://www.theguardian.com/environment/2016/oct/22/four-in-](https://www.theguardian.com/environment/2016/oct/22/four-in-10-uk-councils-exceed-air-pollution-limits-figures-show)
6
7 [10-uk-councils-exceed-air-pollution-limits-figures-show](https://www.theguardian.com/environment/2016/oct/22/four-in-10-uk-councils-exceed-air-pollution-limits-figures-show)
8
9

10
11 Brown, A., Robertson, M, eds, 2014. Economic evaluation of systems of infrastructure provision:
12
13 concepts, approaches, methods iBUILD/Leeds Report.
14
15

16
17
18 Buchanan, J.M., 1965. An economic theory of clubs. *Economica*, 32(125), pp.1-14.
19
20

21
22
23
24 Bulkeley, H.A., Broto, V.C. and Edwards, G.A., 2014. *An urban politics of climate change:*
25
26 *experimentation and the governing of socio-technical transitions*. Routledge.
27
28

29
30 Chatterton, P., 2016. *Building transitions to post-capitalist urban commons*. Transactions of the
31
32 Institute of British Geographers, 41 (4). pp. 403-415. ISSN 0020-2754
33
34

35
36 Castree, N. and Christophers, B., 2015. Banking spatially on the future: capital switching,
37
38 infrastructure, and the ecological fix', *Annals of the Association of American Geographers*, 105(2):
39
40 378-386
41
42

43
44
45
46 Core Cities, 2013. Core Cities Growth Prospectus Policies Step 6: Power Up the Cities, Core Cities,
47
48 Accessed February 2nd 2014 at: [http://www.corecities.com/what-we-do/publications/core-cities-](http://www.corecities.com/what-we-do/publications/core-cities-growth-prospectus-policies-step-6-power-cities)
49
50 [growth-prospectus-policies-step-6-power-cities](http://www.corecities.com/what-we-do/publications/core-cities-growth-prospectus-policies-step-6-power-cities)
51
52

1
2
3 Cumbers, A., 2015. Constructing a global commons in, against and beyond the state. *Space and*
4 *Polity*, 19(1), pp.62-75.

6
7
8
9 Department for Transport., 2016. *Transport analysis guidance: WebTAG*, Available online, accessed
10 August 2016, available at: [https://www.gov.uk/guidance/transport-analysis-guidance-](https://www.gov.uk/guidance/transport-analysis-guidance-webtag#webtag-data-book)
11 [webtag#webtag-data-book](https://www.gov.uk/guidance/transport-analysis-guidance-webtag#webtag-data-book)

13
14
15
16
17 Department for Transport, Department for Environment Food and Rural Affairs (2017), *UK plan for*
18 *tackling roadside nitrogen dioxide concentrations: detailed plan* Available online, Accessed August
19 2017 at: [https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-](https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017)
20 [uk-2017](https://www.gov.uk/government/publications/air-quality-plan-for-nitrogen-dioxide-no2-in-uk-2017)

22
23
24
25
26
27
28 Dummett, B. and Salvaterra, N., 2016. Sovereign-Wealth Funds, Macquarie Buy Stake in National
29 Grid's U.K. Gas-Distribution Unit, Wall Street Journal, December 8th, 2016

30
31
32
33
34 EA Technology, no date, *My Electric Avenue Summary Report*. Available at:
35 [http://myelectricavenue.info/sites/all/themes/meatheme/files/MyElectricAvenue%28I2EV%29-](http://myelectricavenue.info/sites/all/themes/meatheme/files/MyElectricAvenue%28I2EV%29-ProjectSummaryReport.pdf)
36 [ProjectSummaryReport.pdf](http://myelectricavenue.info/sites/all/themes/meatheme/files/MyElectricAvenue%28I2EV%29-ProjectSummaryReport.pdf)

37
38
39
40
41
42 Earle, J., Moral, C. and Ward-Perkins, Z., 2016. *The econocracy: the perils of leaving economics to the*
43 *experts*. Oxford University Press.

44
45
46
47
48
49 Enright, T. and Rossi, U., 2018. Ambivalence of the urban commons, in: Ward, K., Jonas, A.E.G.,
50 Miller, B. and Wilson, D. (Eds.) *The Routledge handbook on spaces of urban politics*. Abingdon and
51 New York: Routledge, 35-46.

1
2
3 Esfahani, H.S. and Ramírez, M.T., 2003. Institutions, infrastructure, and economic growth. *Journal of*
4 *development Economics*, 70(2), pp.443-477.

6
7
8
9 Fei, C., Rinehart, I., 2014. *Taking Back the Grid: Municipalization Efforts in Hamburg, Germany and*
10 *Boulder, Colorado*, Heinrich Böll Stiftung, Washington, D.C.

12
13
14
15 Fisher, J., Gammon, R. and Irvine, K.N., 2015. *SDRC 9.6: An assessment of the public acceptance of*
16 *Demand Side Response of EV charging using Esprit*. My Electric Avenue.

18
19
20
21 Foster, S., 2011. Collective action and the urban commons. *Notre Dame Law Review*, 87, p.57.

22
23
24
25 Frischmann, B.M., 2005. An economic theory of infrastructure and commons management.
26
27 *Minnesota Law Review*, 89, pp.917-1030.

28
29
30
31 Frontier Economics., 2015. Customer Led Network Revolution, Insight Report: Domestic Direct
32
33 Control, Accessed November 2016, available at: [http://www.networkrevolution.co.uk/wp-](http://www.networkrevolution.co.uk/wp-content/uploads/2015/02/CLNR-L096-Insight-Rerport-Domestic-Direct-Control-Trials.pdf)
34
35 [content/uploads/2015/02/CLNR-L096-Insight-Rerport-Domestic-Direct-Control-Trials.pdf](http://www.networkrevolution.co.uk/wp-content/uploads/2015/02/CLNR-L096-Insight-Rerport-Domestic-Direct-Control-Trials.pdf)

36
37
38
39
40 Gateshead City Council., 2016. Gateshead Town Centre District Energy Scheme, Accessed online
41
42 November 2016 at:
43
44 [http://www.gateshead.gov.uk/Building%20and%20Development/Regeneration/GatesheadCentre/G](http://www.gateshead.gov.uk/Building%20and%20Development/Regeneration/GatesheadCentre/Gateshead-Town-Centre-District-Energy-Scheme/Gateshead-Town-centre-District-Energy-Scheme.aspx)
45
46 [ateshead-Town-Centre-District-Energy-Scheme/Gateshead-Town-centre-District-Energy-](http://www.gateshead.gov.uk/Building%20and%20Development/Regeneration/GatesheadCentre/Gateshead-Town-Centre-District-Energy-Scheme/Gateshead-Town-centre-District-Energy-Scheme.aspx)
47
48 [Scheme.aspx](http://www.gateshead.gov.uk/Building%20and%20Development/Regeneration/GatesheadCentre/Gateshead-Town-Centre-District-Energy-Scheme/Gateshead-Town-centre-District-Energy-Scheme.aspx)

49
50
51
52 Gerber, J.D. and Gerber, J.F., 2017. Decommodification as a foundation for ecological economics.
53
54 *Ecological economics*, 131, pp.551-556.

1
2
3
4
5 Hardin, G. (1968), 'The tragedy of commons', *Science* **162**, 1243–1248.
6
7
8
9

10 Hardt, M. and Negri, A., 2009. *Commonwealth*. Harvard.
11
12
13
14

15 Harvey, D., 2012. *Rebel cities: from the right to the city to the urban revolution*. Verso Books.
16
17
18
19

20 Helm, D., 2009. Utility regulation, the RAB and the cost of capital¹ Dieter Helm University of Oxford
21
22 May 6th 2009, Available at: [http://www.dieterhelm.co.uk/assets/secure/documents/Helm-CC-](http://www.dieterhelm.co.uk/assets/secure/documents/Helm-CC-060509.pdf)
23
24 [060509.pdf](http://www.dieterhelm.co.uk/assets/secure/documents/Helm-CC-060509.pdf)
25
26
27

28 Helm, D., 2010. Infrastructure and infrastructure finance: The role of the government and the
29
30 private sector in the current world, in Engel, E., Fischer, R. and Galetovic, A., 2010. Public and private
31
32 financing of infrastructure. *EIB Papers*, 15(1)
33
34
35

36 Helm, D., 2013. British infrastructure policy and the gradual return of the state. *Oxford Review of*
37
38 *Economic Policy*, 29(2), pp.287-306.
39
40
41
42

43 House of Commons (2016) *Air quality, Fourth Report of Session 2015–16*, House of Commons
44
45 Environment, Food and Rural Affairs Committee. Available online, accessed August 2016 at:
46
47 <http://www.publications.parliament.uk/pa/cm201516/cmselect/cmenvfru/479/479.pdf>
48
49
50
51

52 Huron, A., 2017. Theorising the urban commons: New thoughts, tensions and paths forward, *Urban*
53
54 *Studies*, 2017, Vol. 54(4) 1062–1069
55
56
57
58
59
60

1
2
3
4
5 Inderst, G. 2010. "Infrastructure as an asset class", EIB Papers, (15:1)
6
7
8
9

10 Kotchen, M.J. and Moore, M.R., 2007. Private provision of environmental public goods: Household
11 participation in green-electricity programs. *Journal of Environmental Economics and Management*,
12
13 53(1), pp.1-16.
14
15
16
17
18
19

20 Künneke, R. and Finger, M., 2009, June. The governance of infrastructures as common pool
21 resources. In *Workshop on the Workshop* (Vol. 4, pp. 3-6).
22
23
24
25
26

27 Little, R.G., 2005. Tending the infrastructure commons: ensuring the sustainability of our vital public
28 systems. *Structure and Infrastructure Engineering*, 1(4), pp.263-270.
29
30
31
32

33 Lockwood, M., 2016. Creating protective space for innovation in electricity distribution networks in
34 Great Britain: The politics of institutional change. *Environmental Innovation and Societal Transitions*,
35
36 18, pp.111-127.
37
38
39
40
41

42 Lockwood, M., Kuzemko, C., Mitchell, C. and Hoggett, R., 2016. Historical institutionalism and the
43 politics of sustainable energy transitions: A research agenda.
44
45
46
47

48 Meek, J., 2014. *Private island: Why Britain now belongs to someone else*. Verso Books
49
50
51
52

53 Mirrlees-Black, J., 2014. Reflections on RPI-X regulation in OECD countries. *Utilities Policy*, 31,
54
55 pp.197-202.
56
57
58
59

1
2
3
4
5 Moss, T., Becker, S. and Naumann, M., 2015. Whose energy transition is it, anyway? Organisation
6 and ownership of the Energiewende in villages, cities and regions. *Local Environment*, 20(12),
7 pp.1547-1563.
8
9
10

11
12
13
14 Mullen, C., Marsden, G., 2015. Transport, economic competitiveness and competition: A city
15 perspective, *Journal of Transport Geography*, 49, pp.1-8. doi: 10.1016/j.jtrangeo.2015.09.009
16
17
18

19
20
21 Müller, C., 2011. Advancing regulation with respect to smart grids: pioneering examples from the
22 United Kingdom and Italy. *Fourth Annual Conference on Competition and Regulation in Network*
23 *Industries*, Brussels 2011.
24
25
26
27

28
29
30
31 O'Brien, P. and Pike, A., 2015. *The financialisation and governance of infrastructure*. iBUILD Working
32 Paper 8.
33
34
35

36
37
38 O'Brien, P. and Pike, A., 2015a. City deals, decentralisation and the governance of local infrastructure
39 funding and financing in the UK. *National Institute Economic Review*, 233(1), pp.R14-R26.
40
41
42

43
44
45 O'Neill, P.M., 2013. The financialisation of infrastructure: the role of categorisation and property
46 relations. *Cambridge Journal of Regions, Economy and Society*, 6(3), pp.441-454.
47
48
49

50
51
52
53 O'Neill, P., 2016. Managing the Private Financing of Urban Infrastructure. *Urban Policy and Research*,
54 pp.1-12.
55
56
57

1
2
3
4
5 Ostrom, E. *Governing the Commons: The Evolution of Institutions for Collective Action*. New York:
6 Cambridge University Press, 1990.
7
8
9

10
11
12 Ostrom, E., 2006. The value-added of laboratory experiments for the study of institutions and
13 common-pool resources. *Journal of Economic Behavior & Organization*, 61(2), pp.149-163.
14
15
16

17
18
19 Ostrom, E., 2010. Beyond markets and states: polycentric governance of complex economic systems.
20
21 The American Economic Review, 100(3), pp. 641-672
22
23

24
25
26 Ostrom, E., 2010a. Polycentric systems for coping with collective action and global environmental
27 change. *Global Environmental Change*, 20(4), pp.550-557.
28
29
30

31
32
33
34 Ostrom, V. and Ostrom, E., 1977. Public goods and public choices. 1977, pp.7-49.
35
36
37

38
39 Quinn, C.H., Fraser, E.D.G., Hubacek, K. and Reed, M.S., 2010. Property rights in UK uplands and the
40 implications for policy and management. *Ecological Economics*, 69(6), pp.1355-1363.
41
42
43

44
45
46 Radywyl, N. and Biggs, C., 2013. Reclaiming the commons for urban transformation. *Journal of*
47
48 *Cleaner Production*, 50, pp.159-170.
49
50

51
52
53 Rao, B. and Parikh, M.A., 2003. Wireless broadband drivers and their social implications. *Technology*
54
55 *in Society*, 25(4), pp.477-489.
56
57

1
2
3
4
5 Ross, L., Ward, A., 1996. Naïve realism: implications for social conflict and misunderstanding. In:
6
7 Reed, E.S., Turiel, E., Brown, T. (Eds.), *Values and Knowledge*. Lawrence Erlbaum Associates,
8
9 Mahwah, NJ

10
11
12
13 Royal College of Physicians. 2016. *Every breath we take: the lifelong impact of air pollution*. Report of
14
15 a working party. London: RCP, 2016.

16
17
18
19
20 Rutledge, I. and Wright, P., 2011. *UK Energy Policy and the End of Market fundamentalism*. Oxford
21
22 University Press.

23
24
25
26
27 Samuelson, P.A., 1954. The pure theory of public expenditure. *The review of economics and*
28
29 *statistics*, pp.387-389.

30
31
32
33 Stanley, M., 2011, "Investing in Infrastructure: Getting the Conditions Right", *OECD Journal: Financial*
34
35 *Market Trends*, Vol. 2011/1. <http://dx.doi.org/10.1787/fmt-2011-5kg55qw11gr1>

36
37
38
39
40 Stern, J., 2014. The role of the regulatory asset base as an instrument of regulatory commitment.
41
42 *Eur. Networks L. & Reg. Q.*, p.29.

43
44
45
46
47 Webb, J., 2014. Webb: Evaluating Urban Energy Systems in the UK—the Implications for Financing
48
49 Heat Networks. *Science & Technology Studies*.

50
51
52
53
54 Wild, M., 2017. *Energy Consumers' Missing Billions: The profits gifted to energy networks*. Citizens
55
56 Advice, June 2017.

1
2
3
4
5 Wolsink, M., 2012. The research agenda on social acceptance of distributed generation in smart
6 grids: Renewable as common pool resources. *Renewable and Sustainable Energy Reviews*, 16(1),
7 pp.822-835.
8
9
10

11
12
13
14 Yin, R.K., 2011. *Applications of case study research*. Sage.
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
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