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Realigning the electric city.

Legacies of energy autarky in Berlin and Hong Kong

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Abstract: Whilst cities are widely regarded as playing a pivotal role in energy transitions, recent research is highlighting the enormous variety of urban responses. This differentiated picture of urban energy transitions is helpfully opening up the debate to the multifarious factors shaping urban energy policy. What is in danger of getting lost in these powerfully 'presentist' narratives is a sense of where these urban responses are coming from and how historical legacies of energy production and use are influencing future options. This paper uses a comparative historical analysis of two iconic 'electric cities' - Berlin and Hong Kong - to explore the legacies of past socio-technical configurations for today's attempts to realign urban energy systems. It investigates firstly, how, in response to their respective geo-political isolation prior to reunification in 1990/1997, the two cities strove to maximise local energy autarky for security reasons. The paper, secondly, demonstrates how political and economic reintegration in the 1990s has initiated a realignment of each city's energy policy, as power grids become regionalised and local generation capacity questioned. We conclude by drawing implications from these historical legacies of energy autarky and regionalisation for the cities' responses to the low carbon challenge today.

Key words: energy autarky; urban energy transitions; Berlin; Hong Kong

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1. Introduction

Whilst cities are widely regarded as playing a pivotal role in energy transitions, today and in the future, recent research is highlighting the enormous variety in urban responses to climate change (Bulkeley et al. 2011; Rutherford and Coutard 2014; Mai and Francesch-Huidobro 2015). The search for model development trajectories or institutional arrangements for the low carbon city is being clouded by stories of deviation, contestation, appropriation and adaptation peculiar to specific urban contexts and contingent events. This differentiated picture of urban energy transitions as they are really happening is helpfully opening up the debate to the multifarious factors shaping urban transitions and the challenges that emerge from them for both policy and research. What is in danger of getting lost in these powerfully 'presentist' narratives is a sense of where these diverse urban responses are coming from and how historical legacies of energy production and use are influencing (low carbon) options for today and the future.

This paper uses a comparative analysis of two iconic 'electric cities' – Berlin and Hong Kong – to explore the legacies of past socio-technical configurations for today's attempts to realign urban energy systems. The selection of these two cities is informed in part by their symbolic status as pioneers of the modern electrified city. Berlin was Europe's "Electropolis" of the 1920s and 1930s, being home to Germany's powerful electrical industry but also to innovative urban illuminations and lighting festivals (Hughes 1983; Moss 2014; Hasenöhrl 2015). Hong Kong was among the first cities in East Asia to have electric street lighting, in 1890, and has since become a model for safe and reliable power provision in the region and an icon for its illuminated skyline (Waters 1990; China Light & Power (CLP) 2014; Hong Kong Electric (HEC) 2014). Beyond their global symbolism as 'electric cities' the two cities are distinctive because of their unusual histories of autarky of power generation. Both cities have a long experience of being self-sufficient for their own power supplies and having to (re)configure their electricity systems around their own urban territory. This was the case in West Berlin between the blockade of 1948/49 and German reunification in 1990 and in Hong Kong under British colonial rule until its handover to China in 1997 and – to a significant extent – still to this day. For primarily geopolitical reasons, West Berlin and Hong Kong sought to secure their power supplies by maximising urban energy autarky and limiting dependency on their regional neighbours: East Germany and mainland China. Since reunification in the 1990s, Berlin has had to re-align its electricity system to take account of the reopening of borders, the introduction of competition and processes of economic and political integration with surrounding regions. In Hong Kong reunification with China did not alter its high level of autarky in power generation significantly but has made grid connections to, and electricity imports from, China the subject of growing debate (Environment Bureau 2014, 2015). Its electricity market remains in the hands of two de facto monopoly utilities, although liberalisation has been under discussion since 2006 (Woo et al. 2006; Luk 2007; CLP 2015). These energy transitions from urban autarky to regional integration – in the form of rapid re-alignment (Berlin) and gradual rapprochement (Hong Kong) – are accompanied by more familiar policy objectives to reduce carbon emissions, minimise energy use and increase energy efficiency through shifts in electricity generation and use.

The energy histories of these two cities inspire the following research questions, to be addressed in this paper:

- Firstly, how did West Berlin and Hong Kong strive to render their electricity supply systems more autarkic in response to their geopolitical isolation and to what effect?

- Secondly, how have the two cities been realigning their electricity supply systems following reunification in the 1990s?
- Thirdly, how far and in what ways are their historical legacies of energy autarky framing options for energy transitions today?

The paper is conceived not merely as a comparative case study of two 'electric cities' and their historical legacies, but also as a contribution to broader debates on energy autarky, energy security and urban energy transitions. In terms of the avenues for social science research set out in this journal (Sovacool 2014) the paper works at the interface between the politics, geographies and histories of energy. It explores the impact of geopolitics on urban energy systems and the energy security strategies that have emerged in response to infrastructure isolation and subsequent integration. It highlights the spatial dimensions of these strategies, as exemplified in the reconfiguration of electricity networks around the territorial confines of the city. It also advances knowledge on the history of urban energy by illustrating how far and in what ways past events and trajectories influence today's energy systems and their prospects for transition.

We begin by introducing relevant scholarly debates, identifying research needs pertinent to the empirical cases and exploring ways of working at the interface between the approaches presented (Section 2). In the subsequent two empirical sections we investigate, firstly, how, in response to their respective geo-political isolation prior to reunification in 1990/1997, the two cities of West Berlin and Hong Kong strove to make themselves autarkic in terms of solely local electricity generation, building up capacity for energy self-sufficiency (Section 3). We subsequently demonstrate how political and economic reintegration in the 1990s has initiated a realignment of each city's energy policy, in which power grids either have been (Berlin) or are being (Hong Kong) regionalised and local generation capacity questioned (Section 4). In the following section we discuss how these historical legacies of energy autarky and regionalisation are influencing the cities' energy transitions today (Section 5). We conclude by summarising the principal findings and reflecting on their relevance for debates on urban energy transitions in general and on energy autarky and energy security in particular (Section 6).

2. Urban energy transitions: discourses of autarky and security

Much of the literature on energy transitions is, perhaps inevitably, loaded with normativity. Most studies are underpinned with value judgements about the environmental unsustainability of existing energy systems, assumptions about the inherent benefits of alternative sources of energy and preferences for particular forms of governance, such as decentralised power networks or community energy projects. Recent contributions on urban energy transitions by human geographers, political scientists and sociologists have helped rectify the powerful normative thrust of energy transitions research (Bulkeley et al. 2011; Andrews-Speed 2013; Rutherford and Coutard 2014; Mai and Francesch-Huidobro 2015). Their interest in how energy transitions develop in particular urban contexts and their epistemological roots in critical and institutional analysis sensitise these scholars to the problems encountered by, and through, energy transitions in practice. From this corpus of work we have learned, for instance, that energy transitions in cities do not follow a model or linear pathway, they are often highly contested, they tend to overlay, rather than replace, existing modes of energy provision and use and they can generate negative impacts of their own. This literature can, however, be criticised for its strongly 'presentist' perspective on urban energy transitions, focusing on current attempts to promote low carbon cities and relegating the historical legacies of urban energy systems to introductory contextualisation. This research deficit is met to some extent by scholars of urban environmental history and the history of technology who have explored earlier energy transitions, for instance from wood to coal, from gas to electricity or from municipal to national power utilities (Hughes 1983; Melosi 2000). What is still missing, though, is research spanning these two bodies of literature, i.e. studies capable of explaining how the history of a city's energy system is influencing today's energy transitions. This kind of work can be about the path dependence of predominant structures or logics of energy provision in a city, about historically rooted cultures of energy use, about critical events in the recent past (e.g. blackouts) which have influenced subsequent management strategies or about entrenched dependencies of a city on energy imports.

In this paper we offer an illustration of this research potential by setting the ongoing energy transitions in Berlin and Hong Kong in the context of their recent urban energy histories. What makes this endeavour particularly intriguing is that both cities are adapting to a very different kind of transition to their energy systems; namely, the reintegration of their insular urban networks into regional and national electricity systems. In the case of Berlin, technical networks have been re-connected, new organisational structures created, regulatory regimes altered and resource flows redirected. In the case of Hong Kong, such processes of infrastructural and market integration are ongoing. Yet, at the same time, elements of the old autarkic electricity systems still remain entrenched. This offers an excellent opportunity to study processes of reconfiguration – or reassembling – of urban energy networks in a city's recent history, observing which elements change and which do not. It also allows us to investigate not just one energy transition in each city, but two, exploring how today's attempt to pursue a low carbon agenda for each city is constrained or assisted by its legacy of autarky, concerns over energy security and steps towards spatial reintegration.

These issues of energy autarky and energy security in connection with shifting energy geographies resonate with several strands of recent academic debate on (urban) energy transitions. Energy autarky, as discussed in the context of the current energy transition debate, is conceived most frequently in the normative sense of a programmatic vision (Müller et al. 2011). According to Müller at al. an energy autarkic region is one that relies on its own energy resources to sustain society in the region (ibid.: 5801). They define autarky not simply in terms of self-sufficiency of supply but also regarding the energy source (e.g. renewables from the region, rather than carbon energy imports), the decentralised structure of the energy system and increased energy efficiency on both the supply and demand side (Müller at al. 2011: 5802). The related term energy autonomy is also prevalent in the literature, most prominently advanced by Scheer in his popular eponymous book (2007). For him, energy autonomy is similarly oriented around decentralised models of renewable energy systems, although with a focus on autonomous initiatives taken by individuals, local communities or investors. Used normatively in this way, both terms are geared to mobilising support for a particular kind of energy autarky. However, this literature does not reflect critically on the assumptions underpinning the connectivity between autarky, renewables and decentralised organisation, nor does it consider potential drawbacks of energy autarky, such as negative impacts on the surrounding region or issues of legitimacy emerging from community initiatives (Hodson and Marvin 2010). In this paper we use the term energy autarky in a simple, non-normative sense to refer to a policy of establishing self-sufficiency in electricity generation (rather than full energy autonomy) in a specific territory – in our case, two isolated cities. What is unusual in these two cases is that the separation of their power networks from those of their surrounding regions ran counter to the conventional trajectory of integrating urban electricity systems into large-scale networks at a regional and national scale (Hughes 1983; Verbong et al. 2002). Indeed this had been the experience of Berlin prior to political division. Initially served by its own municipal power stations, the city became, from the 1930s onwards, increasingly dependent on the national grid and electricity generated in large-scale power plants located in distant coal-mining areas (Hughes 1983; Hellige 1986). The experience was similar on the Chinese mainland, though not in Hong Kong.

Building autarky into an infrastructure system, such as for electricity supply, is one strategy to increase energy security in cities, the second strand of literature of relevance to this paper. In their work on urban ecological security Hodson and Marvin draw attention to recent trends of cities and their utilities to make their socio-technical networks more resilient to shocks and stresses (2010; Medd and Marvin 2005). They illustrate how energy autarky is becoming a means of increasing urban resilience with the examples of New York City's strategy of energy self-sufficiency and London's ambitious targets for decentralised energy (Hodson and Marvin 2010). The emergent strategy of urban ecological security they identify is about reconfiguring infrastructures to safeguard resource flows and essential services in the face of a growing variety of threats, ranging from impacts of climate change to terrorism and warfare. This work builds on a broader literature on the resilient city (Vale and Campanella 2005) within which urban infrastructures are viewed as playing a key role in resilience strategies for cities (Graham 2010). Under the label 'critical infrastructure' policies are being developed to protect vulnerable infrastructure systems, such as urban energy networks, from disruption in whatever form, whether extreme weather events, resource shortages, human error or terrorist attacks (Aradau 2010; Coward 2009). Research on urban infrastructure failure – whether in the shape of electricity blackouts (Bennett 2005), infrastructure fatigue (Graham and Thrift 2007) or accidents – is generating vital new knowledge about how socio-technical networks are constituted – materially, institutionally and spatially – and how they work (or fail). Interestingly for the Berlin and Hong Kong cases, some contributions to this field of study emphasise the importance of building excess capacity into urban infrastructures as a means of withstanding shocks and maintaining functions in situations of stress (Amin 2013).

This paper contributes to these two bodies of work by exploring connectivity between energy autarky and energy security as components of urban energy transitions. Rather than focusing solely on modern-day debates on making energy systems more resilient through greater self-sufficiency, it investigates two past instances where energy autarky became regarded as a political and technical necessity to secure the continuous and adequate supply of electricity in each city. We aim to show for each case how this came to be, what form energy autarky took, how this is being reordered following reunification and what impacts this historical legacy is having on today's attempts at transition towards a low carbon city.

3. Urban energy autarky as a response to geopolitical isolation

3.1 West Berlin, 1948-1990

It is highly significant, but not widely known, that the Berlin Blockade of 1948/49 began with the cessation of electricity flows to West Berlin. On 24 June 1948 the Soviet military authorities in Berlin instructed the city's electricity utility Bewag, located in the Soviet sector, to cut off all power supplies to the three western sectors of the city (Moss 2009). Deliveries of coal to power plants in the western part of the city were also to cease immediately. This sudden truncation of flows of electricity and coal plunged West Berlin into a supply crisis far more severe than anything experienced during the wartime bombardment and invasion of the city. Astonishingly, most of Berlin's coal-fired power plants had survived the war. Following cessation of hostilities, however, the Soviet occupying forces had dismantled and removed power plants, primarily in the western sector, prior to the arrival of the Western Allies. As a result, the generating capacity of the whole city was reduced by almost one half and of West Berlin by 90% (Brocke and Brüss 1953:113). At the time the blockade began, therefore, West Berlin was extremely dependent on electricity supplied by the power stations in East Berlin and the surrounding region. Not only the generating capacity but also most of the city's coal reserves were at the time stored at power plants in the eastern half of the city (Merritt 1986).

The immediate response of the Western Allies revealed how vulnerable West Berlin was to the power cut-off. The airlift set up to overcome the blockade transported not so much food, clothing and sweets (as is lovingly remembered) as coal needed to keep West Berlin's power stations in operation. Indeed, whole generators were flown in for the rapid reconstruction of Kraftwerk West (Senat von Berlin 1964:736). Notwithstanding these emergency measures electricity use had to be restricted to an average two hours during the day and two hours at night during the winter of 1948-49. Ernst Reuter, then city councillor responsible for utilities and transportation, appealed to West Berliners to consider that "[e]very kilowatt hour of electricity, every cubic metre of gas and every litre of water which is taken from our supply pipes costs coal. And new coal can only be provided by air" (Senat von Berlin 1964: 1482). Per capita consumption in West Berlin fell as a result of these efforts to a mere quarter of East Berlin levels. Parallel to the physical division of the infrastructure networks, the Berlin blockade heralded also the organisational split of the power utility Bewag. The Soviet authorities tried unsuccessfully to depose the director of Bewag, Ernst Karl Otto Strassmann, who had been a liberal resistance group leader and appointed to the post by the Allied powers after the war (Strassmann 2006). Following a lengthy struggle for control of the company it was divided into a West Berlin and East Berlin utility in December 1948 (Merritt 1986).

The end of the blockade on 12 May 1949 did not restore external electricity supplies to West Berlin. Despite a number of agreements on the delivery of electricity from East Berlin over the following years, none of these proved reliable. In March 1952 Bewag-East precipitated the termination of all electricity supplies to West Berlin (Merritt 1986). From then until German reunification in 1990 West Berlin was to remain an 'electricity island', cut off from the national and regional grids of both West and East Germany (Merritt 1986; Varchmin and Schubert 1988; Bewag 1991).

[Insert Figure 1 about here]

Figure 1: West Berlin's truncated electricity system, 1956. Source: Stolpe 1956:277

It is against this prolonged and bitter experience of system vulnerability that West Berlin's subsequent strategy of expanding its electricity generating capacity as much and as fast as possible needs to be understood. The priority was to reduce dependency on East Berlin and the Soviet zone by achieving full energy autarky – at least in terms of power generation (Stolpe 1953; 1956). It was no coincidence, therefore, that one of the first acts of Councillor Reuter following the end of the blockade was to call for the reconstruction of the city's main power station, Kraftwerk West, as a deterrent against similar Soviet interventions in the future (Senat von Berlin 1964:1554). By 1952 this flagship power station had been restored to a capacity of 268 MW, already providing the lion's share of the total 382 MW at West Berlin's disposal (Brocke and Brüss 1953:114). Major extensions were made to other power stations in the boroughs of Moabit, Charlottenburg, Steglitz and Spandau, in line with the expansionist policy of successive Bewag-West directors, from Rudolf Stolpe to Wilm Tegethoff. By early 1955, within an extraordinarily short period of time, Bewag-West had become self-sufficient in electricity generation, largely thanks to credits to fund capital investments from the European Recovery Programme (ERP). By 1984, West Berlin boasted a generating capacity of 2,251 MW, capable of covering the city's electricity demand that year, standing at 8,990 mill kWh (Bers and Strempel 1984; Ziesing 1985). Throughout the period of political division the city remained entirely dependent on shipments of coal (and, increasingly, oil) from outside to run the power stations, but strove to minimise vulnerability to disruption by maintaining huge coal reserves within the city.

There is no indication that Bewag-West seriously considered saving energy and curbing demand as a way of helping secure electricity supply in its precarious insular situation. It continuously defied political pressure to promote demand-side management and, subsequently, renewable energies (Monstadt 2007:329; Moss 2014). This is all the more surprising since the utility, to meet anticipated growth in demand, built up reserves of generating capacity far in excess of conventional levels and had to rely on expensive imported fuel. The predominant strategy was energy security via energy autarky, to be achieved primarily by expanding generating capacity within the city. It took a number of protests against the construction of new power stations in the city, together with the oil crisis in 1973, for Bewag-West to re-consider its expansionist strategy, albeit in a modest way (Monstadt 2004). The company then began advising on energy saving and alternative forms of energy, such as heat pumps and solar collectors. More effort, though, was put into expanding the district heating network, taking advantage of the central location of many of its co-generating power stations. By 1988 17% of heating in West Berlin was provided by district heating systems, compared with 8% in West Germany (Varchmin and Schubert 1988:24). Here we can observe how the strategy of securing energy supply by increasing generating capacity within the densely populated city created new opportunities for combined heat and power generation. A radical policy change was heralded only in 1989 with the election of the city's first social democratic-green coalition, which created an energy task force to promote more efficient power stations, renewable energies and demand-side management and, in 1990, a new state Energy Law setting out an institutional framework for energy planning (SenStadtUm 1990; Monstadt 2007). By then, however, the fall of the Berlin Wall and the reunification of the city had created a completely new setting for energy policy in Berlin.

3.2 Colonial Hong Kong, 1841-1997

Unlike West Berlin, Hong Kong Island had been self-sufficient in energy generation for electricity since power was first introduced to the city in the late 1800s and was to remain so throughout British rule (1841-1997). The first power utility, the Hong Kong Electric Company Ltd (HEC), was established in 1890 by three legendary Hong Kong *taipans* (senior business executives) to serve Hong Kong Island: Bendyshe Layton, the founder of bill and bullion brokers Layton & Co. and an appointed member of the Legislative Council (1888-1889) who provided the momentum, prominent landowner, businessman and philanthropist, Catchick Paul Chater, its first investor and director for 37 years, and William Wickham, who designed and oversaw the building of the first power plant and stayed as manager till 1910 (The China Mail 1918: 4; Waters 1990: 249; The Industrial History of Hong Kong 2015). The company built a succession of coal-fired power stations on the island, beginning with the Wanchai Power Station in 1890 and followed by North Point A (1919) and B (1958), both decommissioned in 1989. By 1916, the south of the Island was connected to a main grid, allowing a number of large companies (Dairy Farm, Taikoo Docks, Peak Tram and The University of Hong Kong) which had previously generated their own electricity to switch to HEC (Waters 1990). Two oil-fired power stations were built in 1966 and 1968 at North Point C and Ap Lei Chau, on the south side of Hong Kong Island. These were also decommissioned in 1989 to make space for residential developments (Hong Kong Electric 2014; Waters 1990: 219-256). HEC began relocating power generation operations at this time to Lamma Island (off the south coast of Hong Kong Island), where it constructed eight coal-fired generators and five gas turbines in operation from 1991-1997. In return for providing a high level of service, HEC was granted a secure source of funding for investments, as set out in a Scheme of Control Agreements (SCA), in force from 1979-1992 and subsequently renewed (Hong Kong Electric 2014). According to the SCA, the government requires that "...service to the consuming public continues to be adequate to meet demand, to be efficient and of high quality, and is provided at the lowest cost..." (Federation of Hong Kong Industries 2005: 1). In return, "the government recognises that the companies and their stakeholders are entitled to earn a return which is reasonable in relation to the risks involved and the capital invested in and retained in their business" (ibid.).

In the Kowloon Peninsula and the New Territories of Hong Kong, the history of electricity began in 1901, when the China Light and Power Company Syndicate (later CLP Power Hong Kong Ltd) was incorporated with investments from the trading company Shewan Tomes and Co. in 1890 and in 1930 with investments from the Kadoorie family, Sephardic Jews who came to Hong Kong from Shanghai in the 1880s and one of the wealthiest families in Hong Kong today (CLP 2014; Waters 1990: CLP 2015; Clifford 2015: 188). The first CLP power plant (oil-fired) was opened in 1903 at Chatham Road, Hung Hom, with a generating capacity of 75kW, providing street lighting from 1919 onwards. During the Japanese occupation (1941-1945) CLP commissioned in 1940 an oil-fired power station at Hok Un, Hung Hom. It consolidated its generating capacity during the 1950s and 1960s, purchasing the Tai O (Lantau Island) Power Company in 1955 to supply Lantau Island and commissioning another oil-fired power station at Tsing Yi in 1969 (CLP 2014). Like HEC, CLP concluded a Scheme of Control Agreement with the Hong Kong government for the period 1978-1992, followed by a second covering the period 1993-2008. The reliance on oil ended following the oil crisis of 1973, with the commissioning of the coal-fired power stations Castle Peak A in Tuen Mun (1979) and Castle Peak B (1986). In 1989, CLP supplied electricity to nearly 1,400.000 customers in Kowloon, the New Territories, Lantau, and some outlying islands. Subsequently, gas-fired power stations were built by the company at Penny's Bay in the eastern part of Lantau (1992) and at Black Point (1996).

[Insert Figures 2a and 2b about here]

Figure 2a: First Map of Hong Kong 1841. Source: Photo by Francesch-Huidobro of exhibition hall Hong Kong Museum of Coastal Defence

Figure 2b: Map of Hong Kong 1941. Source: Photo by Francesch-Huidobro of exhibition hall Hong Kong Museum of Coastal Defence

During the 1980s CLP began to look beyond the territory of the British colony and take initial steps towards connecting the Hong Kong power system to that of the Chinese mainland. It had started selling electricity to Guangdong province as early as 1979. In 1985 CLP signed the Daya Bay Joint Venture with the Chinese government. On the basis of this agreement, CLP – together with Guangdong Nuclear Investment Company (GDNC) – commenced construction of a pressurised water reactor nuclear power station in Daya Bay, Guangdong Province, commissioned in 1994 (CLP 2014). Also in 1985, CLP adopted a business model including a commitment to develop wind and hydro power in mainland China (Chow 2001).

In sum, Hong Kong's colonial period was characterised by a stable electricity regime built up around the two territorial monopolies of HEC and CLP. Geopolitical isolation encouraged both to pursue a strategy of securing safety and reliability of supply, safeguarding resource flows and maintaining affordable services within the city. Until the Daya Bay nuclear plant was commissioned in the mid-1990s, Hong Kong was entirely self-sufficient in its power supply. Its dependence on external fuel sources did, however, prompt shifts during the century, notably from oil to gas and nuclear following the oil crisis.

4. Reintegrating infrastructure in response to reunification

4.1 Berlin, 1990-present

The fall of the Berlin Wall and the reunification of Germany in 1990 brought to an abrupt end West Berlin's status as an 'electricity island'. After 40 years of technical and organisational division caused by geopolitical isolation the immediate tasks were to reconnect the power supply systems of East and West Berlin, amalgamate the two power utilities and link the West Berlin electricity network to the national and European grids (Bewag 1991; Winje 1994; Monstadt 2004). Overcoming these technical and organisational ruptures proved relatively straightforward over the following years. In 1990 the power utility of East Berlin was amalgamated into West Berlin's Bewag. A provisional 110 kV cable was laid between East and West Berlin in December 1992 to provide additional reserve capacity in the event of a power shortfall in West Berlin (Winje 1994). A permanent 380 kV cable connecting West Berlin to the national grid followed in 1994.

What proved far harder for Berlin's electricity system post-1990 was adapting to an energy market and policy context which was becoming increasingly competitive, diverse and environmentally sensitive (on the following Monstadt 2007: 330-335). The initial economic impact of German unification on Berlin was to precipitate the collapse of its traditional industries. This resulted in a fiscal crisis in the early 1990s and the call to meet this with the sale of assets. Most of the city's utilities were subsequently sold, including its majority shareholding in Bewag in 1997. The new owners – a consortium of private energy companies subsequently bought out by the Swedish utility Vattenfall – were contractually bound to maintain specific standards of service and environmental protection, as well as a commitment to invest in Berlin, but their performance was not monitored by the city government (ibid.:331). The following year, 1998, Germany's electricity market was liberalised in accordance with European legislation, requiring the freshly-privatised Bewag to compete for business. Without its territorial monopoly for power supply in Berlin, the utility sought to remain competitive by cutting costs, primarily in investments to the network, but also in environmental protection, R&D activities and consumer services (ibid.:332).

It is in this context of market liberalisation and cost-cutting that the power generating capacity built up during the years of division to keep West Berlin powered suddenly became a commercial liability. The inner-city power stations constructed in the post-war years had been designed to serve energy security interests, not low-cost electricity provision, and many proved uncompetitive in the new national (and European) electricity market. Consequently, seven power plants in the former West Berlin, with a total generating capacity of 1,884 MW, were closed down between 1999 and 2005

(SenWTF 2011:45). This had the positive side-effect of reducing CO_2 emissions within the city significantly. Between 1990 and 2011 CO_2 emissions from electricity consumption in Berlin fell by nearly a half, from 13.385 to 6.747 million tonnes (Amt für Statistik 2014:33). This can only in part be attributed to the modest decline in the city's electricity consumption by 14% over the same time period, from 49,352 to 42,334 terajoules (ibid.:25). However, the downside of decommissioning inner-city power stations has been to reduce substantially the city's district heating capability, since most of them produced heat as well as power. As Berlin dismantles its over-capacity in unprofitable coal-fired electricity generation, the city is becoming increasingly reliant on power from outside the city, primarily from lignite-fired power stations in the neighbouring region of Lusatia (part of Brandenburg and Saxony). This has been raising criticism for some time that the city is seeking to meet its CO_2 reduction targets by importing a growing proportion of its electricity from outside, disregarding the impacts on the climate. The proportion of electricity generated in the city using renewables is, by national comparison, low, at 7.0% in 2011 (ibid.:27). A major plan to increase this share substantially by building two 150 MW plants run on biomass at the existing Klingenberg power station was shelved in 2014 following protests by residents against the anticipated disturbance from transporting the high-volume fuel to this inner-city site.

[Insert Figure 3 about here]

Figure 3: Dismantling the Oberhavel power station in Berlin, 2007. Source: Photo by Moss

In terms of energy policy, the conservative-social democratic city government formed in 1990 pursued the path set out by its red-green predecessor, but with far less enthusiasm. The Energy Concept for Berlin of 1994 targeted a 25% reduction in CO_2 emissions between 1990 and 2010 and included an energy-saving action plan, covering housing, public buildings, transport, energy services and renewable energies (Monstadt 2004). Responsiveness to climate change became, for the first time, an issue of energy security. In the early 1990s new organizational structures were created, such as the Berlin Energy Agency and the Energy Coordinating Unit within the Senate Department for Urban Development and the Environment, which provided important groundwork for today's energy transition in the city. However, the city government was not prepared to force Bewag to prioritise energy efficiency, especially not following its full privatisation in 1997. In the absence of serious regulatory pressure on its own utility, the Berlin government resorted to public funding for projects planned under the Energy Concept. As the city's debt spiralled from 1992 onwards, funding for these projects dropped sharply. Henceforth, the city relied increasingly on private contractors to implement its energy-saving programmes – to limited effect.

In 2010, under a social democratic-socialist party coalition, the city government adopted a new Energy Concept targeting a 40% reduction in CO_2 emissions by 2020. The city aims to set new standards for sustainable urban energy policy in promoting greater energy efficiency and renewable energies (SenWTF 2011). The experience of Berlin's energy policy following reunification (Monstadt 2004:493-6) cautions, however, against over-optimistic expectations of a strategic shift in direction. Beyond state policy, though, there are interesting recent initiatives for the city or its residents to take over ownership of the city's power grid, following the expiry of the current concession in 2015, and to set up a new municipal power utility which is more environmentally sustainable, democratically accountable and socially responsible than the incumbent Vattenfall (Moss et al. 2014). Furthermore, liberalisation has encouraged the emergence of new 'ecopreneurs' in Berlin's energy sector, particularly active in micro-scale combined heat and power generation and in energy efficiency contracting (Monstadt 2007).

4.2 Hong Kong, 1997-present

The return of Hong Kong to Chinese sovereignty at the stroke of midnight on 30 June 1997 did not unleash a process of physical and institutional integration of two distinct energy systems as witnessed in Berlin. Unlike the case of Berlin, Hong Kong's electricity system had, from its early beginnings until only recently, been completely separate to that of mainland China. Any form of integration between the Hong Kong and Chinese networks following reunification was, therefore, not about restoring a former status of connectivity, but about developing new modes of interaction under the constitutional principle of "one country, two systems", whereby "the socialist system and policies will not be practised in the Hong Kong Special Administrative Region (HKSAR), and the previous capitalist system and way of life shall remain unchanged for 50 years" (Wesley-Smith 1998; NPC-PRC 1990).

At first glance, little appears to have changed to Hong Kong's power system since 1997. The two incumbent power utilities, HEC and CLP, continue to own and operate the grids and supply electricity in their respective areas of the city. Although other power suppliers can freely enter the Hong Kong market, none has yet chosen to do so. The strategy of both utilities to build up capacity to ensure reliability of supply is enshrined in the SCAs agreed with successive Hong Kong governments from colonial times to the present. Mechanisms in the SCAs, such as the permitted rate of return based on average fixed assets, encourage investment in capital works dependent on the amount of electricity sold, thus stimulating, rather than minimising, demand. Hong Kong continues to consume high levels of electricity. For example, CLP's maximum demand in 2013 was 6699 MW, while sales that year amounted to 31.8 billion KWh serving 2.43 million customers. In 2013 HEC had a maximum demand capacity of 2453 MW, providing 0.57 million customers with 10.8 billion kWh of electricity (Information Services Department 2014). Fossil fuels still dominate the fuel mix for power generation in Hong Kong, with coal accounting for 53% in 2012, followed by imported nuclear energy from mainland China (23%), natural gas (22%) and renewables (2%) (Censtatd 2013).

Insert Figure 4 about here]

Figure 4: Daya Bay Nuclear Power Plant, Canton, China, 2012. Source: Photo by Francesch-Huidobro

A closer look, however, reveals that Hong Kong's tradition of autarky in power generation and supply is gradually being undermined. New developments since the return of sovereignty to China are marked by the growing prominence of cross-border electricity transfers, the opening up to wider energy markets, policy initiatives to mitigate climate change and public pressure for greater demand-side management. These developments are, in very different ways, challenging the Hong Kong government and the two city utilities to give up the traditional policy of energy autarky through network expansion and to seek greater regional integration.

An early indication of this shift was the public consultation on an extended SCA for CLP and HEC conducted in 2005. The recommendations emerging from this exercise included the creation of an independent regulatory authority empowered by law to supervise a gradual liberalisation of the electricity market after 2008, favouring access to providers of renewable energy, and a reduction in the rate-of-return incentive driving network expansion (Francesch-Huidobro 2014a & b). Intriguingly in terms of energy autarky, the recommendations also required HEC and CLP to purchase electricity from mainland China when available and cheaper than local production (Economic Development and Labour Bureau 2005). A Memorandum of Understanding was signed between Hong Kong and China in 2008 to promote energy cooperation, specifically over the continuous supply of nuclear power and natural gas from China.

A second driver of change has been climate policy. Following its obligation to meet the Chinese government's CO_2 reduction targets set in 2009, the Hong Kong government has committed itself to reducing greenhouse gas emissions by 50-60% by 2020, in excess of the national target of 40-45%. This commitment was subsequently specified in a consultation document, *Hong Kong Climate Change Strategy and Action Agenda 2010* (Environmental Protection Department 2010). The strategy proposes a radical shift in Hong Kong's electricity generation fuel mix, increasing the shares of natural gas to around 40% and of nuclear power provided from mainland China to 50% by the year 2020 (Environmental Protection Department 2010: 43). Despite its high ambitions for climate mitigation, this policy has been widely criticised by environmental non-governmental organisations in Hong Kong not only because of safety concerns over nuclear power but, more importantly, because of the absence of demand-side management measures to reduce peak electricity demand and end-user energy consumption (Francesch-Huidobro et al. 2014). Energy efficiency is, however, being promoted by the Hong Kong government, for instance within the SCAs agreed with the utilities, which include a scheme to co-fund energy refurbishments in non-commercial buildings, also via mandatory energy labelling for consumer goods (Environmental Protection Department 2010).

In 2014 and 2015 two consultation exercises were conducted to gauge public opinion on options for generating Hong Kong's electricity and for the future development of its electricity market following the expiry of the current SCA in 2018 which capture some of the concerns and aspirations surrounding greater regional integration and competition (Environment Bureau 2014; 2015). Presented with the choice between importing more electricity from the mainland China power grid or using more locally generated electricity from natural gas, coal and renewable energy, public opinion appears to favour the latter. At the 5th international conference on energy policies and technologies which took place in Hong Kong in October 2014 stakeholders from user groups, political parties, environmental NGOs and research organisations voiced concerns not only about the reliability of electricity supplied from mainland China (Wan 2014), but also about the time required to build the cross-border interconnector in an untested process (CLP 2014). Particularly contested is the creation of a Regional Transmission Organisation in the Pearl River Delta Region (Hong Kong's hinterland), which may be used to advance a unified grid and power services between Hong Kong and the mainland. Results of these public consultations have not been published, as we write (Environment Bureau 2015).

The option for more locally generated power is, however, also not free of problems. Increasing the share of natural gas to 60%, as envisaged for this option, would create new dependencies on the West-East Gas Pipeline from Turkmenistan via China, following the depletion of gas resources from the South China Sea gas field Yacheng 13-1 off Hainan Island, as well as on liquefied natural gas sourced from Shenzhen, Guangdong Province. Retaining nuclear energy at around 20% of electricity generation would also bolster dependence on China for energy and – despite more stringent safety standards at the Daya Bay nuclear plant – is the subject of growing criticism following the Fukushima accident of 2011 (CLP 2009; CLP 2013; Wan 2014). Finally, the expansion of renewable energy sources for Hong Kong is severely limited by its physical geography. High urban density and a lack of space restrict the use of solar and wind power on the territory. One wind turbine has been in operation since 2006 at the Lamma power station. In March 2013, HEC completed the expansion of its solar power system in Lamma Power Station from the 550 kW installed in 2010 to 1 MW (HEC 2013). The two power companies HEC and CLP are currently exploring the feasibility of building large-scale offshore wind farms with a total installed capacity of 300 MW, but even this would cover only 1.5% of Hong Kong's electricity consumption (CLP 2014). Given these physical, as well as political, limitations to change, the incumbent utilities point to their past track record of very high service reliability and relatively low tariffs as a strong argument for retaining the status quo (CLP 2015, email communication).

5. Legacies of local autarky and regional realignment for energy transitions today

Having explored in the previous sections how each of the two 'electric cities' developed their own forms of energy autarky in response to their geopolitical isolation and how they are currently realigning their electricity systems to fit conditions post-reunification, we now turn to our third research question and consider how these historical legacies are framing options for energy transitions today. The purpose of this section is not to provide additional empirical material, but to discuss what we have presented in terms of how the past is influencing the present and future options. In conceptual terms this is about considering the degree to which current developments in both cities can be considered path dependent. Path dependence is a process by which future choices are restricted by development trajectories of the past (North 1990), for instance when policy legacies constrain current policy options (Kay 2005). The concept has been widely applied to explain the obduracy of socio-technical systems (e.g. Melosi 2000), but has been criticised for being far less able to explain change (Hay 2002; Kay 2005) or the effects of disruptive events (Verbong et al. 2002). This differentiation is important to the following interpretation of continuity, contingency and change in our two 'electric cities' post-reunification.

Looking across the two cases, the first and most obvious observation to make is that the experiences of energy autarky made during and after periods of geopolitical isolation do not fit into neat categories of isolation versus integration. The energy pathways pursued by each city may have been powerfully influenced by the desire to seek security in autarky of electricity generation, but they were never completely independent of the outside world, as the reliance on external fuel sources and latter-day grid connections to the hinterland show. Conversely, political reunification in either case did not cause the legacies of energy autarky to lose their relevance overnight. They continue to influence current policies and practices of energy provision and use in Hong Kong and Berlin; not in a deterministic and overpowering way, but in a more subtle and selective manner. This may be an obvious point, but it is by no means trivial. It guides us to analyse, in this section, the extent to which these historical legacies are framing today's urban energy systems.

1. ***Legacies of territorial integrity***: During their respective periods of geopolitical isolation both cities sought to develop autarky of electricity generation and supply to defend their territorial integrity. The vulnerability of West Berlin's power supply to the blockade of 1948/49 was formative in redesigning its electricity system around the geography of a divided city, with new, inner-city power stations covering for the loss of imported electricity. West Berlin's history of territorial protection – as a response to forced separation – is today largely insignificant in the reunited city. In Hong Kong, by contrast, the legacy of territorial integrity build up by the British to protect its colony remains a key issue today in terms of relations with mainland China. Ongoing debates on

closer cooperation with China over Hong Kong's future electricity supply are powerfully framed by fears of Hong Kong losing its ability to pursue its own policy agenda.

2. ***Legacies of protected markets***: The local power utilities in West Berlin and Hong Kong were instrumental in maintaining territorial integrity by providing reliable energy services. To this end they were protected from competition and allowed to operate territorial monopolies. This was, of course, the norm in many countries prior to liberalisation from the 1980s onwards, but the separation of Bewag in Berlin from the national grid during the years of political division and the self-dependence this cultivated made the transition to a liberalised electricity market after 1998 especially hard, resulting in cost-cutting and plant closures to remain competitive. In Hong Kong, the SCAs agreed between the government and the two power utilities were explicitly designed to protect HEC and CLP from market competition in return for securing a high and reliable level of service. Since successive SCAs have been modified in only a modest way, Hong Kong's electricity system remains characterised, essentially, by two vertically integrated territorial monopolies.

3. ***Legacies of supply security***: Securing electricity supplies at all times and under any circumstance was the guiding principle of energy policy in both cities during their geopolitical isolation. To allow for potential disruption of service – whether owing to political intervention or delays in accessing fuel sources – huge capacities for generation were built up in each city, in the shape of multiple power stations and grid extensions. It is interesting to note that neither city seriously pursued the option of minimising electricity consumption and, thereby, reducing the need to expand capacity. It is likely that the availability of mechanisms to finance this strategy of network expansion – whether the cost recovery stipulations in SCAs (Hong Kong) or the European Recovery Programme (West Berlin) – made it persistent. The legacy in both cities is continued reliance on the logic of build-and-supply to the detriment of demand-side management. Establishing energy efficiency on the policy agenda is, for this reason, proving difficult in Berlin and Hong Kong.

4. ***Legacies of local infrastructure***: The construction of sufficient power stations within its own territory posed a particular challenge in both cities. Particularly in Hong Kong, competing claims on land for residential and business purposes caused inner-city power plants to be replaced by ones at increasingly peripheral locations. In Berlin after 1990, the problem lay rather in how to deal with the legacy of its urban power stations in a reintegrated and liberalised energy market. Designed during the years of division to maximise generation capacity and secure continuous supply, these power stations were ill-equipped to compete, proving a commercial liability to the utility Bewag. Several were consequently decommissioned during the 2000s, but at the price of losing a substantial proportion of Berlin's district heating capacity as most were cogeneration plants.

5. ***Legacies of resource flows***: Energy autarky in West Berlin and Hong Kong was always only limited to electricity generation, as both were dependent almost entirely on fuel imports to run the power stations. It is interesting to observe a gradual process of diversification of fuel sources over the years – also largely for geopolitical reasons – in particular in Hong Kong. Originally both cities were heavily reliant on coal to fire their power stations. This was supplemented by oil (especially for CLP's power stations) until the oil crisis of 1973, after which there was a shift towards gas and – in Hong Kong's case – to imported electricity from nuclear generation. This heavy dependence on fossil fuels for generating local electricity is today creating difficulties for both cities to achieve the

ambitious CO_2 reduction targets they have set themselves. Pressure to deliver on climate mitigation goals is tempting both city governments to reduce local generation and import more electricity. This practice is criticised by environmental groups for concealing the fact that the CO_2 emissions are merely being produced elsewhere.

6. ***Legacies of environmentalism**:* Both West Berlin and Hong Kong have – relative to their respective hinterland – a strong tradition of local environmentalist movements and initiatives, arising partly in opposition to the dominant energy strategy of their governments and utilities. The alternative cultures of both cities, attracting especially young people interested in unconventional lifestyles and a more open society, have also nurtured support for green politics. These protagonists of sustainable forms of energy provision and use range from environmental non-governmental organisations campaigning for more effective climate protection measures to 'eco-preneurs' marketing energy-saving technologies or services. They all play a crucial role in ensuring that the energy transition policies of their respective cities are not the preserve of the political and business elites.

Amongst these different legacies we can detect some degree of path dependence, but only with respect to certain dimensions of the socio-technical systems. Issues where self-reinforcing mechanisms from the past are constraining future options include Hong Kong's political culture of territorial integrity vis-à-vis China, the security-driven logic of build-and-supply in both cities and their dependence on fossil-fuel generating capacity. By contrast, our comparison has revealed several counter-intuitive findings where path dependence might have been expected, but did not occur. The spatially reconfigured electricity network for West Berlin, for instance, was reintegrated into the national grid with surprising ease, post-1990. Similarly, the physical embeddedness of Hong Kong's inner-city power stations has not prevented their removal to make way for urban development. In both cities the obduracy of a fossil-based, supply-oriented energy policy has engendered strong environmentalist opposition as a major force for change.

6. Conclusions

As empirical research into urban energy transitions and low carbon cities reveals how diverse and distinctive these can be, greater attention needs to be paid to the historical roots of different urban energy pathways. The purpose of this paper has been to draw attention to the ways in which today's urban responses to climate change and energy security are framed by historical legacies of local energy systems and their embeddedness in – or disconnection from – wider regional, national and transnational structures. To illustrate the non-linearity and contestation of urban energy pathways we deliberately chose for study two cities whose current attempts to address climate change are, we argue, shaped by their histories of self-reliance in power generation. For Berlin and Hong Kong are not only iconic 'electric cities', but gained considerable experience in maintaining autarkic supplies of electricity in the face of geopolitical division (Berlin) and isolation due to colonisation (Hong Kong). Their histories as 'electricity islands' have not been erased by processes of political and economic reunification in either case. The legacy of energy autarky lives on, in very different ways, in both cities, creating particular challenges for realigning their energy systems to meet new requirements of climate change, market competition, energy security and regional cooperation. Realigning the 'electric city' effectively means taking its history seriously.

In response to our first research question, we revealed the measures by which West Berlin and Hong Kong sought to render their electricity supply systems more autarkic in response to their geopolitical isolation. Unable to rely on a regional or national power grid, both cities responded by building up and sustaining their own power generation capacity capable of meeting all electricity needs, with substantial reserves to cover for emergencies. Energy security – in the sense of securing supply at all times – was the priority concern; creating energy autarky through capacity expansion was the strategic response. Within this powerful supply-driven logic there was no place for measures to curb demand, although this could have reduced critical loads of electricity consumption. Energy efficiency was only advanced (modestly) from the 1980s onwards under pressure from environmental groups. Nevertheless, the strategy of energy security through autarky proved effective in both cities. Power services were never subject to significant interruption throughout the years of division and standards of service and safety were high.

In response to our second question, we then demonstrated how each city has been realigning its electricity supply system since reunification in 1990 (Berlin) and 1997 (Hong Kong). Here, the experiences are markedly different. For Berlin, the reconnection of the power grid and the reunion of the city's power utilities were rapid and relatively straightforward. Problems of adaptation emerged, rather, from concurrent processes of economic restructuring in Berlin and liberalisation of the German electricity market. The past strategy of building up expensive generating capacity within the city proved highly unsuited to the new environment of open competition and fiscal austerity, prompting the decommissioning of many inner-city power stations and increasing electricity imports. In Hong Kong the process of adaptation is more gradual. The city's electricity market remains protected, in the hands of its two power utilities HEC and CLP, and three quarters of Hong Kong's huge electricity demand is still met by local generation. However, the past 10 years have seen intense debate about the future viability of energy autarky for Hong Kong. Not only energy security issues, but also climate mitigation interests are being enrolled in arguments to increase the degree of connectivity to mainland China, importing more electricity and thereby reducing the need for local generation in power stations driven by fossil fuels.

Turning to our third question, we reflected on how historical legacies of local energy systems are framing urban responses to climate change and energy security today. Looking across the experiences of the two cities, we categorised the findings in terms of six distinct, but interdependent, legacies of energy autarky relating to territorial integrity, protected markets, supply security, local infrastructure, resource flows and environmentalism. These categories helped reveal and interpret some of the principal differences, but also similarities, between the two cities' current situations. In Berlin, the most influential factors from its history of division would appear to be, on the one hand, the physical infrastructure built for energy security that is no longer commercially viable and, on the other, the dominant supply-oriented logic of the incumbent power utility. One can also count the city's active environmentalist movement that is driving many innovative low-carbon projects as, at least in part, a product of protest against this powerful logic. In Hong Kong, similar pressure for more sustainable energy systems is revealing severe structural weaknesses behind its long-standing strategy of energy autarky. If the city wants to meet its own ambitious targets to reduce greenhouse gases, it will need to reduce electricity generation from its coal- and oil-fired power stations substantially. In the absence of any significant reduction in demand, alternative sources of electricity from nuclear, low-carbon or renewable sources will be required. Given Hong Kong's physical geography, this will mean greater dependence on mainland China, raising new issues of energy security. The post-reunification trajectories of both cities, we found, do not fit neatly into simple categories of path dependence on the one hand or serial contingency on the other. Parts of their electricity systems reveal a high degree of path dependence, whilst others do not at all.

On the basis of these observations we, finally, draw some conclusions on the significance of this study for current debates on energy autarky and energy security and their role in urban energy transitions. There are obvious limitations to generalising from the experience of such exceptional, iconic cases. The value of studying West Berlin and Hong Kong lies not in any model status they may be ascribed, but in what their unusual histories can reveal about urban energy transitions that is absent or less visible in other cities with more conventional trajectories. In terms of energy autarky and energy security the stories of Berlin and Hong Kong make very clear that these concepts have not always been interpreted in the ways they are today and that their meanings can be very different in particular spatial-temporal contexts. The energy autarky pursued in West Berlin after the blockade and throughout colonial Hong Kong did not follow today's normatively loaded understanding of an entity aspiring voluntarily to local self-sufficiency based on renewable sources, low demand and citizen participation. For these two cities it was, rather, imposed upon them by geo-political circumstances and involved securing electricity supply *without* having to change practices of consumption, technologies of generation or governance structures. This suggests we need to question assumptions about what energy autarky can be and what forms it can take. Our two cases suggest that it can be a geopolitical necessity and a mode of energy security, but also a restriction on future energy options and an inefficient use of energy resources. Similarly, energy security can mean different things at different times and in different places. Both Berlin and Hong Kong have to come to terms with rapidly shifting meanings of energy security. What was once principally about protecting their energy systems from hostile neighbouring states, today encompasses a variety of concerns ranging from climate protection and ecological security to fuel availability and terrorist attacks.

Future research on urban energy transitions would benefit from unpacking these notions of energy autarky and energy security in terms of how they are interpreted and used in energy policy and research. Beyond this, our study has argued that historical legacies are hugely important to understanding urban energy transitions. Here, it is not enough to acknowledge that history matters. We need to reveal *how* history matters, for instance in the ways in which some components of an urban energy regime remain obdurate, some disappear or are discarded, whilst others adapt to shifting contexts or emerge in the wake of contingent events. The processes by which these socio-technical components get realigned – or re-assembled – are often contested and non-linear. Although strongly influenced by the past, they are not determined by it. This points scholarship in the direction of more nuanced studies of socio-technical legacies, unpacking the dynamics and continuities of the "seamless web" and its multiple components (institutional, technical, geographical, social etc.). The two stories also sensitise us to the context-dependency of energy policies. The strategy of both cities to build up huge capacities for power generation that elsewhere would be viewed as expensive, inflexible and unwise was, in their situation, essential to secure supply. Finally, our study warns against taking too myopic a view on cities when analysing urban energy transitions. The energy histories of Berlin and Hong Kong cannot be studied as purely urban phenomena: the pursuit of energy autarky was in direct response to their geopolitical situation; the realignment today is equally influenced by their relations with surrounding territorial entities. We need to acknowledge and explore the multiple ways in which urban energy transitions are shaped by, and themselves shape, regional, national and international developments.

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