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Splintering Networks:
Cities and Technical Networks in 1990s Britain

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INTRODUCTION

The past fifteen years has seen a remarkable shift in the regulation and management of infrastructure networks on the United Kingdom. Wide scale privatisation of water, waste, gas, electricity and telecommunications networks has transformed the United Kingdom into a vast laboratory, with innovative new techniques of controlling urban technical networks being implemented and evaluated (Ernst, 1994). Over a brief spell of frantic activity new technologies, regulatory regimes, management styles, marketing strategies, environmental priorities and commercial goals have emerged, dramatically re-configuring patterns of infrastructure provision within British cities.

Many of these key changes have gone virtually unnoticed, with almost all analyses of urban processes largely ignoring the critical importance of infrastructure provision in the production of the built environment (Diamond and Spence, 1989) Awareness of the impact of privatisation in the United Kingdom has been limited to media hype around executive pay and share options with little understanding of the wider socio-technical ramifications of such a swift liberalisation of the ownership and management of urban infrastructure networks.

This paper seeks to start developing just such an understanding. In particular the paper aims to critically problematise the whole approach of urban analysts to the creation and development of urban technical networks. Rather than take for granted universal access to utility services, by simply assuming infrastructure provision to be a technologically homogenous and social cohesive activity, we will point to the emergence of key disjunctures between social, environmental and commercial priorities introduced by the privatisation process. Critically we will stress the urgent need for spatial sensitivity in unpacking the social, environmental and commercial impact of different regimes of infrastructure provision. In doing so we will equate the privatisation of urban technical networks with a process of spatial, institutional and social 'splintering' in the delivery, development and management of urban technical networks.

The process of 'splintering networks' has a number of dimensions. Firstly 'splintered networks' are not organisationally unified or integrated. They are characterised by competition between service providers in a mix of competing private companies. A second characteristic of the 'splintered' utility marketplace is the orientation of utility providers who tailor their 'product' according to the local needs of niche, profitable markets. Styles of provision vary across the country and importantly, between different classes of consumer. Thirdly, 'splintered' utility networks are shaped by local and regional demand and will therefore develop highly unevenly. Such splintering of what was hitherto (al least in aspiration) nationally-homogeneous technical systems has shifted the socio-technical logic governing infrastructure provision. On the one hand, increased levels of social polarisation are surfacing as the quality of service

provision becomes much more spatially contingent (Graham and Marvin, 1995). On the other hand, stringent commercial priorities are encouraging higher levels of technical efficiency with beneficial environmental results.

Measuring the benefits and drawbacks of privatisation/liberalisation of urban technical systems is, then, a messy business. Effective analysis demands temporal awareness of the changing logics guiding the management of infrastructure provision ; sectoral knowledge of the varying physical and regulatory constraints guiding the emergence of this new splintering logic in different utility sectors ; and spatial sensitivity to the local, regional, national and international impact of the privatisation and liberalisation of urban technical systems. This paper aims to provide an effective guide to this process. Focusing on electricity, telecommunications, gas, waste and water networks, we will develop an analytical framework for analysing the radical transformation of technical networks over the last fifteen years in Britain. The paper is divided into four sections.

First, we develop a sympathetic critique of existing conceptual approaches to the study of urban technical networks. Based upon an analysis of the remarkable shifts in the regulation and development of these systems in Britain we challenge the assumption that urban technical networks simply evolve along expansionary, integrated, standardised, publicly-accountable and homogeneous trajectories.

Second, we analyse the transformation of urban technical systems in the United Kingdom since the implementation of the Conservative privatisation process of the 1980's. In particular we focus on the 'splintering' of infrastructure networks and the creation of complex new 'patchworks' of urban technical systems. Focusing on individual networks we trace the process by which these new splintered networks are rapidly replacing the largely-standardised and homogenous networks that developed over the post war period.

Third, we build upon this analysis to identify the social, economic and environmental logics emerging from this process of rapid change. Here we will highlight the heterogeneous socio-environmental impact of 'splintered' urban networks by comparing and contrasting socio-economic processes of 'cherry picking' - the growing competitive focus of privatised utility companies on lucrative niche markets - and 'social dumping' - the easing out of economically marginal domestic markets - with the environmental benefits of increased network efficiency.

Finally, we conclude by drawing together the implications of the shifts for the governance of British cities. There are currently few links between conventional urban government and the development of splintered urban infrastructure systems by which urban policy makers can address the contradictory effects of cherry picking and social dumping and wider environmental questions. With national policy makers virtually blind to the

impact of these dramatic new logics guiding infrastructure provision we will argue for new policy approaches to minimise socio-spatial polarisation while maximising environmental benefits.

A Sympathetic Conceptual Critique

The explicit study of utility technical networks - water, energy and telecommunications - in urban disciplines is remarkably rare. Since Lewis Mumford's path-breaking books addressing the links between such tecehnologies and urban history (Mumford, 1934;1938), only a few urban historians have attempted to understand how cities and technical networks co-evolve (Tarr, 1984; for a review, see Konvitz et al, 1990). Most work on utilities has come under the wider auspices of research on the field of Large Technical Systems (LTS) - the massive systems linking physical technological artefacts, organisations, and suporting scientific practices in advanced capitalist society (Hughes, 1987). Analyses of the development of Large Technical Systems (LTS) has historically been largely conducted within Social Studies of Technology and allied disciplines (LaPorte, 1994). These have been concerned to understand how inventors, entrepreneurs, technologies, markets and regulations interplay to shape the growth, evolution and extension of technical networks (see, for example, Hughes, 1983; Mayntz and Hughes, 1988; Konitz et al, 1990)). The most celebrated of these was Thomas Hughes' detailed study of the early years of electricity development in the UK, USA and Germany (Hughes, 1983). In such approaches, technical networks are seen to reflect as well as shape the wider socio-political context within which they emerge (Gokalp, 1992).

Most studies in this area have taken an explicitly historical perspective, tracing in detail how small, fragmented urban utilities first developed in particular cities in a symbiotic relationship with early processes of industrialisation. Each local system tended to develop with different technologies, different standards, different styles, different degrees of municipal support and regulation, and different tariffs (see, for example, Hall and Preston, 1988; Jackson, 1987; Hughes, 1983; Paul-Simon, 1993). Thus, this era can be termed one of *localisation* (see Figure 1). A complex 'utility patchwork' developed based on separate 'islands' of gas, electricity, water and phone networks which could often not be interconnected because of their technical differences (Graham and Marvin, 1995).

As part of the shift towards extensive urban-industrial regions in the early twentieth century, these early systems were gradually extended and 'stabilised' (Hughes, 1983). In the language of Social studies of Technology, they merged to 'become obdurate' as the now familiar socio-technological assemblies we take for granted at the national level: national phone networks, national energy grids and wide area water networks (Bijker and Law, 1992; Beltran, 1992). Economies of scale, effective management of variable loads and demands, a logic of

technological standardisation and modernisation and the imperatives of national industrial competitiveness all had a role to play here (see Hall and Preston, 1988). These priorities echoed the wider political imperatives of nationalisation that surfaced with post-war Keynesian approaches to macro-economic management. In infrastructure terms there was an urgent need to address the problems caused by fragmented, unreliable and uneven supply of utility services, both as a stimulant to industrial modernisation and regional development and as a spur to consumer demand and social progress. Only through national regulation could this occur. As Thomas Hughes puts it, the general lesson from this period is that "in modern industrial nations technological systems tend to expand" (Hughes, 1987; 71).

These shifts resulted in the emergence of more homogenous, standardised utility networks, integrating national space economies and urban systems into functional wholes in a (relatively) seamless way (LaPorte, 1994; Paul-Simon, 1993). The merging of diverse 'utility fragments' into single national networks in turn provided the 'sinews' which underpinned the massive urbanisation of the period and the elaboration of modern metropolitan economic and social life (Konitz et al, 1990). Such technological infrastructure, although largely now taken for granted, actually "makes possible the existence of the modern city and provides the means for its continued operation" (Tarr and Dupuy, 1988; ix) through the continuous flows of energy, water, waste, information and services that these grids underpin.

Thus, the history of sich networks supports the perspective that the logic of such networks is generally expansionary, with a general shift noted from the era of *localisation* (with many locally-controlled gas, electricity, telephone and electricity networks developing symbiotically with local industrial districts), to one of *nationalisation* (where pressures for national growth management and Keynesian regulation lead to pressures for integrated, standardised utility networks regulated at the national level) (Graham and Marvin, 1995) (see Figure 1). Responsibility and power over technical networks thus shifted from the local to the national levels, with the emergence of bureaucratic agencies and utility boards to oversee the 'roll out' of nationally-integrated networks on as homogenous and standardised pattern as possible. Because of the vast capital investment involved in the 'rolling out' of national utility grids, they were seen to be natural monopolies and even quasi-public goods (Sleeman, 1953). Thus markets were protected with monopoly legislation so that the necessary cross-subsidies could take place between the most profitable markets and routes (industrial users and urban areas) and the unprofitable ones (largely rural areas and poor districts). This shift was symbiotically linked to the wider elaboration of a mass production, mass distribution and mass consumption-oriented political economy during the post war boom.

As such networks become more and more standardised and ubiquitous, the evolution of technical systems is often seen as

as having attained a largely autonomous 'momentum' : to be basic, stable and strategic underpinnings to urban-industrial development which no longer justify detailed scrutiny and can be left packed inside an analytical 'black box' (Hughes, 1987;77). In short, they become *taken for granted* - a fact reflected in the paucity of treatment in the urban literature. This leaves a paradox: whilst all aspects of the functioning of cities rely intensely and continuously on such networks at every stage, they are largely invisible and ignored in discourses on cities (Graham and Marvin, 1995). In fact, they only tend to arouse real attention when they *fail* or *collapse* (La Porte, 1994).

But there are increasing signs that the assumptions underlying this treatment of technical networks and urban development are increasingly out-of-date. A global wave of liberalisation and/or privatisation of national utilities is fundamentally reshaping the ways in which urban technical networks are developing. Publicly- accountable or state-owned utility bureaucracies are being transformed into profit-hungry corporations searching for maximum rate of return on their investments in a globalising context (Graham and Marvin, 1995). Niche markets are being explored for maximum profit and complex layers of competition are emerging whereby old utility firms and new entrants attempt to poach the most profitable customers from the incumbent monopoly. Cross-investment between previously separate utilities is growing; diversification beyond the sector is increasingly common. Information technologies are being applied pervasively to the 're engineering' of utility operations, offering radically new potential for controlling and reshaping these vast systems (Graham and Marvin, 1994). And, above all, new geographical dynamics are emerging driven by international liberalisation in financial flows, service markets, GATT and the European Commission's attempt to develop a Single European Market for utility services. These globalising forces are pushing private utility companies to both re-embed themselves at the regional, urban and municipal level whilst simultaneously attempting to piece together truly trans-national utility systems. Thus, a nationalisation logic is being replaced by one which mixes complex combinations of *globalisation* and *localisation* (see Figure 1). As this 'splintering' process manifests itself through reduced cross-subsidies, the erosion of standardised tariffs and the selective implementation of innovative technologies a marked unevenness in the quality of utility services offered in different cities and in different sectors of the market is emerging. In this way the logic of nationalisation is being replaced by a logic of global-localisation.

These rapid trends undermine old assumptions that the logic of supply of infrastructure networks is to fill territories with standardised, expansionary, homogenous services which can the be largely taken for granted as an unproblematic technical exercise. They also suggest that there is an urgent need to explore the emerging relations between technical networks and the economic, political, social and environmental development of cities in this new utility era. As we shall see in the next section, no nation

demonstrates these points better than Britain, where the most radical privatisation and liberalisation processes have recently emerged.

The Transformation of Urban Technical Networks in the UK

In this section we analyse the transformation of LTNs in the UK in the emerging era of global-localisation, starting with the radical privatisation programme of successive Conservative governments in the 1980s. Looking across the package of water, energy and telecommunications networks, we trace how new splintered networks are rapidly replacing the standardised and homogenous networks that developed over the post war period. We focus on the remarkable 'splintering' of these technical networks and the creation of new 'patchworks' of LTNs. While LTNs have developed unevenly in the UK in institutional, spatial and temporal terms, with considerable variation across the networked services, we offer a broader framework to analyse the evolution of utility networks. Figure 1 identifies three different periods of network development (see Graham & Marvin 1995). While this represents something of an oversimplification we contend that the similarities and resonance's within each period are more significant than the specific historiography's of individual networks. The aim is to provide a useful conceptual tool in tracing the development of urban technical networks.

Building Networks

Localisation refers to the initial stage of network development. A patchwork of small private and municipally owned enterprises were responsible for the establishment of urban networked services. Rapid urbanisation from the 1840s was based on an increasing dense lattice of technical support services - initially water, waste and gas but later followed by electricity, transit systems and the telephone (Ausubel & Herman 1988; Tarr 1984; Tarr and Dupuy 1988). This bundle of support services facilitated urban growth and development overcoming the social, environmental and economic constraints to the formation of dense urban agglomerations. Early networks tended to follow broadly similar patterns of development - they focused on dense urban cores with the highest demands targeted at particular types of local markets - while the telephone and electricity looked to large business and commercial users (Forty 1986, Preston 1990), water was directed towards households in the interests of improving public health (Chant 1989) while gas was initially focused on public lighting. The configuration of these early networks were largely shaped by local economic, social, political and spatial considerations. Consequently there was enormous diversity in tariffs, levels of connection, the spatial extent of networks, type of service in terms of voltage and quality of gas (Dimcock 1933). These early networks can be characterised as 'islands', they were small, locally based and internally focused

with a high levels of technical, social and economic variability between cities.

Expanding Networks

Nationalisation was the antithesis of this model of network development. The post-war centralisation of utility networks within large public owned national corporations swept away local control of urban networks (Sleeman 1953). There was increasing concern that the small fragmented islands of utilities networks imposed serious constraints on levels of national economic and social development. Variable tariffs, non-standardised systems, differential types of services, low levels of domestic connections rates and inefficient systems were all widely perceived as seriously constraining national economic growth and comparative economic performance with Britain's closest competitors (Dimcock 1933). This led, in the interwar period, to an uneven and highly contested shift towards greater central planning in network management. From the late 1900s there were a series of initiatives to be develop more nationally integrated inter-urban networks. Nationalisation of the telephone network in 1911, the creation of regional electricity networks in 1926, the creation of regional water undertakings in was all part of this process of imposing a greater degree of standardisation and central co-ordination over network development.

During W.W.II there was little resistance to central government intervention in the provision and management of networked services which demonstrated the economic benefits to following a more centralised approach utility planning. Although the need for further rationalisation of the utility industry's gained recognition during the war, the strength of the post-war Labour victory finally swept alternative models aside. With nationalisation of key aspects of the British economy established, large public corporations were given sole responsibility for infrastructure provision. Nationalised corporations were supposed to be free from ministerial or political influence to efficiently and effectively manage public service monopolies in the national interest (Coombes 1971, Reid & Allen 1971, Sleeman 1953). While the technological parameters of network management were ill-defined it was routinely accepted that public utility corporations were charged with rolling out national networks, extending networks into rural areas and completing the connection of domestic households. Tariffs and levels of service were standardised as the utilities created networks to serve an increasingly national rather than local economic space. The extension of utility networks into the domestic sector helped to create new markets for consumer goods underpinning national post-war industrial development.

A new logic of network management slowly emerged during the nationalised period of utility control. Perhaps the most important dynamic guiding the evolution of these technical networks was an extremely powerful supply-oriented logic of network development. Expansion of utility networks became

intimately connected with the drive to improve national economic performance and quality of life. Levels of energy consumption, connection to water and waste networks and levels of telephone ownership became surrogate indicators for levels of national economic performance. In the search for greater economies of scale the electricity industry built larger power stations and upgraded the national electricity transmission network. In the space of twenty years following the second world war, generative capacity multiplied seventeen fold (Reid & Allen,1970, p9). Driven by the basic assumption that economic growth would generate new demands for utility services network providers became locked into a logic of network management that focused on the supply of networked services. Major investments in national transport, energy and telecommunications services were made during this period in order to develop standardised systems of network supply.

Guided by this new logic the specific needs of individual cities had little impact on the process of network provision and management (Graham and Marvin 1995). Although cities were critically important as centres of growing demand the management of networked services was primarily concerned with nation-wide economic development, with national priorities guiding strategic decisions. Regional arms of the utilities began to act merely as sales and marketing departments for powerful central planning agencies. As the power base of nationalised energy industries shifted to remote coal and nuclear fired power stations, and resistance to pylons on conservation grounds mounted in the countryside, the politics of infrastructure provision moved beyond cities. With the light of municipal control extinguished through post war nationalisation relatively little room remained for urban politicians and planners to intervene within the decision-making process guiding infrastructure provision. As the hidden, unseen, quiet and unobtrusive networks expanded, providing utility services for customers at standardised prices and tariffs, little local interest was shown in the social, economic and environmental profile of networked services within cities.

Splintering Networks

Privatisation has radically challenged the logic of network management established during the nationalised period. These changes are having significant changes for the development of technical networks in contemporary cities (Marvin and Graham 1994).

During the 1970s the nationalised period of utility development came under increasing pressure as the supply-side logic of network management became harder to sustain (Vickers and Yarrow 1989). The energy crisis of the early 1970s exposed the costs of a fuel strategy purely based on supply side measures. Increasing constraints on public expenditure meant that the funding of supply oriented measures became severely strained (Houlihan 1992). There was increasing concern about the failure of supply

oriented public utilities. On the social side there was increasing concern about the impacts of rising energy prices on the fuel poor (Boardman 1991). Environmentalists were critical of the failure to seriously pursue energy conservation and efficiency measures while the development of new power stations and coal fields became increasingly controversial. In its commitment to achieving economies of scale in the generation and sale of electricity, its monopolistic, prescribed pricing structures and its inflated capacity, the Central Electricity Generating Board (CEGB) came to be seen as an arrogant producer, uncaring of local demand (Bonner,1989). At another level there was criticism of a perceived infrastructure crisis due to the failure to invest in old and ageing energy and water networks while telecommunications infrastructure lagged behind competitor countries (Cowie et al 1984). In response the government attempted to improve the economic efficiency of the utilities sector through financial controls, targets and increased rates of return. It was widely felt that the sector was inefficient, lacked clear objectives and operated outside wider political control (Vickers and Yarrow 1989). Although various measures were considered for restructuring the utilities sector through the 1970s there was widespread failure to implement comprehensive operational changes.

During the 1980s a solution to the problems of the utility sector developed around the Thatcheritie privatisation project. The basic rationale for privatisation was based on a critique of the nationalised sector. This comprised a number of key justifications - the sector was inefficient and overmanned, unaccountable, union dominated, stagnant and failed to innovate. In the early years the debate was simply based on a shift from public to privatised monopolies (Gas and BT). The central assumption was that privatised management would transform the nature of the industries improving levels of service, increasing efficiency and produce more responsive industries. The new industries operated within a regulated framework designed to protect consumer interests and promote the efficiency of the sector. Increasing criticism of the performance of privatised monopolies created the pressure to increase levels of competition.

Although privatisation and liberalisation has developed unevenly across the utilities sector we can explore how the two processes have increasingly led to the splintering of utility networks creating a new logic of network management which challenges the old assumptions of standardised and homogenous networks of the nationalised period. Figures 2 and 3 provide a conceptual tool around which we can began to unpack our concept of splintering. While the early privatisation's failed to develop a framework that facilitated competitive pressures in the utility sector - later privatisation's and changes in the regulatory structure of already privatised industry have attempted to increase competition. Within each industry these pressures have helped drive the splintering of key aspects of utility networks. There has been fundamental shift away from vertically integrated

monopoly networks to new models of network management that facilitate new entrants and enhance competitive pressures in each of the utilities sectors.

Competitive pressure have been hardest to introduce in to the water sector. Although OFWAT monitors the comparative economic efficiency and performance of the 39 companies, the largely regional structure of the water networks and the difficulties of allowing competitors access to another companies infrastructure have seriously constrained competition. However, OFWAT has encouraged competition on the boundaries of water companies service areas. For instance, as figure 5 suggests, a large user siting a development on the boundary between two companies could choose their supplier while another alternative could include a supply from British Waterways Board through the canal network. Clearly the space for competitive pressures in supply are extremely limited.

Competitive pressures have been more successfully introduced into the energy sector. Although British Gas was privatised as a vertically integrated company regulatory pressures have forced the company to take measures to allow competitors access to the transmission and distribution network. Increasing controversy about the charges for access to the incumbent network have created demands for a more transparent pricing structure - British Gas has been forced to split its transmission structure into a separate business framework. Competitors now supply over 50% of the industrial and commercial market. In 1998 limits on competition will be reduced further when experiments in competitive supply within the domestic sector further erode British Gas market. At this stage it is not clear how domestic competition will work - whether areas will be opened up for alternative suppliers or individual consumers can opt for a competitor.

These issues are easier to resolve in the electricity sector. Figure 2 illustates how at privatisation the sector was broken down into different elements - generation, transmission and distribution. After the criticism of the constraints the privatised British Gas was able to use to delay competitive pressure there was a conscious attempt to introduced more competition into the electricity sector. At the level of electricity supply new technologies have played a crucial role in opening up the distribution network to competitive supply. Large users are able to choice their supplier utilising smart metering technologies to monitor consumption and send readings electronically to their supplier. A new virtual market in electricity supply has been created by overlaying a new telecommunications infrastructure over the electricity distribution network. Although there are still many uncertainties around the implementation of the new smart metering systems competition depends upon, the domestic market will be opened up for competition through regulation in 1998. Those domestic customers with smart meters will be able to choice their

electricity supplier, with all transactions handled electronically over the new telecoms infrastructure.

Figure 3 demonstrates the extremely complex patterns of network splintering in the telecommunications sector. Although new entrants to the telecommunications market can interconnect with the local and trunk parts of the incumbents BTs network new entrants in the UK market have developed their own new networks. At the local level cable TV companies offer telephony and several mobile systems compete for market share, with the largest competitor Mercury having cabled large users in city centres. Regionally the cable TV companies are offering services between franchise areas while the regional electricity companies have now started offering services in their franchise areas. Nationally Mercury have a trunk network layered over the rail network while Energis (Northern Electric) operate a system layered over the electricity supergrid. These multiple networks now create complex new forms of network interconnection - a cable TV may handle the local part of a call, Mercury provide the national trunk while BT carry the local loop. The effect is that users may no longer know which part of multiple telecommunication networks carry their call traffic. With the domestic market due to open up for competition in 1998 based on the installation of a smart metering infrastructure for domestic users the commercial opportunities are endless.

Utility networks are being splintered in different ways in each sector. Basically in water, gas and electricity markets new entrants are being allowed access to existing networks. While there is still a single distribution network companies have been able to gain access to the network to offer competitive supplies. New technology has played a central role in enabling single networks to be overlain with complex telematics systems to enable competitive supplies to pass through monopolistic networked systems. There are of course restriction on these in the water sector but where companies sit on the boundaries between two water companies they are able to take supplies from alternative companies or water networks such as canals and rivers. Telecommunications has a completely different logic with access to BT networks available and a whole range of new entrants at local, national and international level.

These forms of splintering are generating new logics of network management. The utility marketplace is fast becoming segmented and stratified. Large commercial and industrial users are currently enjoying more choice than small domestic users. However in 1998 the domestic market will be open to competition in the gas and electricity sectors. As new logic's of network management sweep through the infrastructure sector the concept of standardised, integrated homogenous networks, with a largely undifferentiated market base, is becoming increasingly untenable. These large technical systems have literally been torn apart as different elements of utility networks are split apart and reconfigured. A new logic of network management is revealing itself as privatised utilities adjust to the new uncertainties

created by regulated markets for utility services. Figures 5, 6 and 7 show how new patchworks of utility companies are springing-up offering a wide range of different services to targeted niche markets. This commercial logic creates new social, economic and environmental concerns and priorities with significant implications for the development and management of cities. Furthermore these shifts fundamentally challenge established frameworks of technical network analysis.

Emerging Logics of Network Management

The whirlpool of change initiated by the introduction of privatisation and liberalisation of utility markets has radically re-oriented the priorities and practices of local utility companies. The en-suing splintering of urban technical networks has, in turn, had a profound impact on the social, spatial and technical logics driving infrastructure provision. Assessing the social and environmental benefits and dis-benefits of this process is not as straightforward as many commentators on the privatisation of public utilities propound. While one camp decries the inequities introduced by privatisation (Ernst, 1994), another celebrates the fresh opportunities for the consumer (Saunders and Harris, 1994). Such totalising verdicts homogenise a spatially dynamic and contradictory social process. Closer investigation of the emergence of new styles of utility network management reveal complex patterns of social, economic and environmental change.

The key shift instigated by the privatisation and liberalisation of utility markets has been the replacement of the ethic of public service - the ideal of cheap, reliable, universal access to utility services for all irrespective of income or location - with the goal of profitability. The overriding aim of British utility companies today is the maximisation of profits. Their master is now the shareholder rather than the general public. The results is mounting pressure on utility companies to find novel ways of extracting surplus value from their networks. This quest has led to the emergence of three related social, economic and environmental logics which increasingly guide the management and development of urban technical networks in the United Kingdom. Figure 4 illustates the characteristics of these 3 logics; cherry picking, social dumping and demand side management.

Cherry Picking

Privatisation and liberalisation of utility of the marketplace has encouraged a keen sensitivity to the market potential of infrastructure provision. The provision of electricity, gas, water, telecommunications is no longer seen as a functional utility service. Instead private utility companies see themselves as selling quality services. Regional Electricity Companies are typical. REC's no longer simply see themselves as supplying standardised kW/hrs, they sell energy services - the ability to boil kettles, heat bath water, light offices and factories etc

(Owen, 1994). Like any other commercial business privatised utilities are keen to tailor their products and services to the most lucrative sections of the market. Customers who consume regularly, pay reliably, and utilise direct debit facilities. No longer classifying 'utility users' simply in terms of their technical profile - their rate of consumption - 'utility consumers' are now being classified in terms of their commercial value. The operational goals of utility companies are then primarily geared towards the attraction, retention and satisfaction of these key customers through quality utility services. Again the electricity sector is typical. Free energy audits, individually tailored tariffs, swift personal advice and trouble-shooting characterise the new marketing strategies of the privatised regional electricity companies. As Carl Weinberg puts it, Utilities "have learned that their survival in a competitive world depends on an ability to understand what it is their customers want", and that "customers are not necessarily interested in low-cost kilowatt hours, but instead in low-cost, high-quality energy services" (Weinberg,1994: 291).

No longer in the business of supplying users with a common resource equally, the utility marketplace is fast becoming stratified and segmented. Moreover, private utility companies are keen to focus their investment in geographically bound areas or 'hot spots'. The best example is the City of London where more than a dozen telecommunication companies are currently competing for the lucrative custom of multi-national financial services companies (Graham and Marvin, 1994). This process reflects the growing internationalisation of the utility marketplace, mirroring privatisation and liberalisation. Keen to seek out ever more lucrative markets, national utilities are reaching out beyond national boundaries in an effort to forge global networks of power and communications. Similarly, energy and water companies are taking on an increasingly international profile with British companies active in the developing markets of eastern europe and the far east while other european companies take-up the commercial opportunities offered by the liberalised British market.

Social Dumping

Those 'cherry picked' consumer groups and 'hot' geographical spaces targeted by competitive utility companies will be the beneficiaries of a host of cheaper, more reliable, individually tailored services. From the standpoint of these niche markets privatisation and liberalisation of utility services appears a wholly beneficial innovation. However, competition creates winners and losers. The corollary of a cherry picking strategy is the social dumping of unprofitable consumers and the withdrawal from zones of little commercial opportunity (Graham and Marvin, 1994). In rural areas and disadvantaged inner cities competition remains scarce, with poor levels of prospective income and high operational costs deterring new investment. At the same time the gradual removal of the cross-subsidies that underpinned the rolling out of national utility networks in the post war period

highlights the 'real' cost of servicing commercial 'cold spots', forcing up prices and lowering the quality of local infrastructure. As utility companies globalise their operations in search of higher returns the capacity of disadvantaged communities to revive local economic fortunes is diminishing. This process graphically highlights the changing spatial economy of the splintering of infrastructure networks. As urban and rural zones become dis-connected or 'dumped' from global networks of power and communications whole regions are becoming socially and economically polarised.

Most worrying is the fate of the poorest domestic consumers who are gradually being edged off utility networks. Such customers are likely to be low consumers of utility services with poor payment records. As such they are viewed as an impediment to the global aspirations of utility companies who are seeking to minimise technical and administrative expenditure while maximising income. With universal service obligations being gradually eroded utility companies are striving to lever poor domestic customers off their networks, a strategy implicit in recent tariff reforms. Service charges have risen at rates higher than the rate of inflation across all utility sectors. These rises have had a differential impact on different classes of user. Typical is British Telecom's policy of radically increasing the costs of local calls and line rental charges which hits poorer local users hard, while reducing the cost of national and international calls to satisfy lucrative business markets (Murdock and Golding, 1989). High deposits are targeted at customers with poor payment records while prepayment systems have been introduced to ensure pay per use. These prepayment meters further serve to marginalise the utility poor by masking levels off dis-connection. Inability to pay for energy, water or communications does not require action on the part of the utility company as user effectively disconnect themselves from the network. As figures 5 and 6 make clear, such technological and fiscal innovation is at the heart of splintered infrastructure network management.

Demand Side Management

Focusing exclusively on the socio-economic implications of the splintering process can result in an overly negative view of the impact of privatisation and liberalisation of utility networks. While worries over the fate of marginalised, 'uneconomic' spaces and users is clearly legitimate it can mask the more positive, environmentally beneficial effects of a more competitive approach to infrastructure provision. This is not to say privatising utility markets leads to environmental sensitivity in any inevitable sense! The environmental outcome of the splintering of networks varies according to the physical, commercial and regulatory constraints shaping different utility sectors and to the specific operational priorities shaping local, regional and national utility strategies.

The electricity sector provides some clear examples of the environmental opportunities provided by privatisation and liberalisation (Guy,1994). During the nationalised era electricity demand profiling was the responsibility of the Central Electricity Generating Board who placed more emphasis upon the avoidance of spectacular "blackouts" than the less dramatic concern of distribution losses (Berrie,1992 pxx). With investment in new infrastructure now in the hands of the REC's, closer attention is being payed to the operational efficiency of the distribution network feeding electricity supplies. While flat, predictable demand has always been the idea goal of electricity planning (Nye,1992), REC's have a particular interest in minimising distribution losses in order to avoid any unnecessary purchase of electricity from the national 'Pool'. This is stimulating refined management of regional supply networks. Greater efforts are being made to tailor the demand profiles of inter-connecting spatial elements to smooth local demand-profiles, thereby minimising the loss of 'electrons' that could be translated into profit. At the same time the energy audits, more detailed demand profiles and multiple tariffs increasingly offered by regional electricity companies in order to win new customers are encouraging users to alter their patterns of demand, their "load profile", to achieve significant electricity savings (Bennell,1994).

Similarly, new tariff structures is allowing a continuously varying price (per kWh), matching as near as possible the actual costs of generation, transmission and distribution. As Tom Berrie points out, such 'spot' pricing has benefits for producers and consumers alike, encouraging; operating efficiency improvements, "capital investment reductions, improved consumer options on supply quality or reliability, and lower electricity prices" (Berrie,1992,pxxvi). Dynamic pricing presents real incentives for users to tailor their electricity needs to a changing structure of supply. On over-stretched networks the avoidance of electricity use at peak periods may help to smooth the demand-profiles, reducing the need for environmentally damaging infrastructure investment.

Private water companies are similarly striving to improve the efficiency of their ageing networks in which leakage levels can reach levels of 30%. With the Office of Water Regulation (OFWAT) now examining efficiency in terms of water delivered to customers, rather than water supplied into the system, a new emphasis on demand management and planning has surfaced. Hitherto local incidences of water stress would be solved within a wider supply strategy, a new reservoir or abstraction point. Now, with all major capital expenditure under review water stress is being dealt with at a local level. Urban zones suffering high water stress are targeted and demand management programmes instigated through 'beyond the meter' water management in commercial and industrial premises and metering of domestic consumption.

This sensitivity to the dynamics of water demand is emerging more gradually than in the electricity sector. With metering still

only accounting for a minority of water-usage, and physical limitations to increased industry competition, water companies are being forced to redefine network management priorities less by commercial expedience and more by regulatory signals. While electricity suppliers experience little environmental regulation, the control of abstraction licenses by the environmental regulator, the National Rivers Authority (NRA) is encouraging the abandonment of supply-oriented management strategies. Similarly, the focus of OFWAT on the 'costs of paying for growth' means that the reshaping of demand through refined network management is increasingly the only viable alternative massive supply-side infrastructure investment.

The environmental implications of the telecommunications revolution are yet more uncertain. Since the 1970s there has been considerable interest in the potential for substituting telecommunications for much more energy intensive forms of communication such as car and air travel (see Harkness, 1977, Kraemer, 1982, Kraemer & King, 1982). Most of the evidence clearly indicates that the direct substitution of a trip by a telephone call consumes significantly less energy. The use of teleworking or teleconferencing systems could help reduce energy use, traffic congestion and air pollutants if they directly substitute for a trip. Urban policy makers in California have developed teleworking initiatives in response to the environmental problems associated with car use in the state (State of California, 1990). Although most emphasis has focused on the environmental benefits of teleworking there are other forms of tele-services such as telebanking, teleshopping, teleeducation, information services and entertainment and leisure services which may have the potential to reduce demand for transport services.

However, although there are substantial savings to be made by substituting telecommunications for travel, once the extra energy costs of heating and lighting the energy inefficient home are taken into account, these savings are much reduced unless the teleworker is substituting for a particularly long commute to work (BT, 1992b, CEED 1992). There is also concern that the road space created by the teleworker would simply be filled by new commuters and that the time the teleworker saves in commuting will be replaced by an increase in leisure and recreational travel.

Even more disturbing is the considerable body of evidence that telecommunications do not simply substitute for travel but that they have a much more complex complimentary relationship. For instance telecommunications can generate travel that would not have occurred without the telecommunications link (Mokhtarian 1990). The development of cheaper, more accessible and efficient telecommunications means that it possible to increase the number of people in a business or leisure network. Once the initial contact has been made electronically the need for a higher level of interaction can actually stimulate new demand for travel (Saloman, 1986). Telecommunications can also increase the

efficiency and effectiveness of travel. New booking, information, payment, traffic management and air traffic control systems can all enhance the attractiveness of travel and perhaps help increase the likelihood of a trip. Rather than telecommunications simply displacing or substituting for older transportation networks the evidence seems to indicate that they can actually generate new demands for travel and enhance the efficiency of transport networks. This synergistic or complimentary relationship between telecommunications and transportation illustrates the real difficulties in making simple assumptions about the potential environmental benefits of the technology.

So, while it is evident that the creation of a liberalised marketplace for the development and management of utility networks and the implementation of innovative technologies is not inherently benign, significant opportunities for enhanced environmental sensitivity across utility sectors clearly exist. Taken together, the social, economic and environmental effects of the splintering process are uncertain, and spread unevenly across utility sectors and across local, regional, national and international space. Blanket assumptions of the evils or virtues of the privatisation and liberalisation of infrastructure services is then misplaced.

Conclusions

In the new infrastructure age of global-localisation the development and management of utility networks has emerged from the shadows of the urban fabric. The social, economic and environmental issues raised by the emergence of the new logics guiding infrastructure provision means that the study of large technical systems can no longer be dismissed as a dull technical exercise in tracing the inevitable evolution of technologically standardised, spatially homogeneous utility networks. The introduction of competition between utility providers, leading to new marketing strategies of niche marketing, social dumping and increased spatial polarisation, has thrown the political ramifications of contemporary utility strategies into sharp relief. The lessons for the study of large technical systems are critical and clear. Firstly, to sharpen the focus of research into the changing logics guiding infrastructure provision through increased temporal, spatial and sectoral sensitivity to utility network development. Secondly, to highlight the apparent dis-connection of local, national and international policy-making mechanisms from these liberalised local-global processes. Thirdly, to develop new regulatory frameworks which safeguard the interests of the utility poor while maximising the wider environmental benefits to be captured from new commercial concerns with network efficiency.

Research into the changing development pathways of large technical systems must urgently focus on the temporal contexts shaping utility strategies. In this paper we have explored the

shifts in the priorities and practices characterising the evolution of infrastructure networks in the eras of localisation, nationalisation and local-globalisaton within the United Kingdom. Such an approach has allowed us to both reveal the contingency of hitherto taken for granted technological processes and to unpack the wider social, economic and environmental effects of the emergence of new logics of network management as illustrated in figure 8. With processes of liberalisation and privatisation of utility services spreading rapidly across europe and the rest of the world international comparative research has become crucial. If we are to develop a critical understanding of the impact of trans-national infrastructure networks we must both learn the lessons of the British experiment and share the joint experience of globalisation. This international awareness must be allied to an increased spatial sensitivity to the localised effects of splintered utility strategies. Tracing the shifting networks of power, water and telecommunications across rural spaces, urban zones and diverse regions is increasingly likely to reveal social inequity, economic unevenness and environmental costs and benefits. Finally, research into these large technical systems must attune itself to the ways in which the varying physical and regulatory characteristics of each utility sector encourages or inhibits technological and commercial innovation, so fashioning the social, economic and environmental profile of individual infrastructure services.

The splintering of utility networks has serious implications for urban governance. Privatisation and liberalisation of infrastructure provision appears to sever links between utility companies and policy making mechanisms. The electricity sector is typical. In this paper we have demonstrated how, as a new logic of network management emerges, privatised electricity companies are emerging as important regulators of energy flows in the territories they serve. Driven by a desire to maximise the techno-commercial efficacy of their energy systems, innovative regional electricity companies (RECs) are increasingly concerned to balance local supply and demand. Accordingly, REC's are reaching 'beyond the meter' in order to actively manage local energy consumption. However, rather than analysing how the intensity of energy flows are being shaped by privatised utility companies, British energy and environmental policy makers have tended to adopt a 'rational' modelling approach increasingly divorced from the operational realities of the restructured energy sector. Typically, policy-makers emphasise the role of land use planning as a mechanism for implementing energy policies. But this approach severely limits energy management opportunities, restricting energy efficient innovation to new forms of development. Instead, it is imperative that energy and environmental strategies recognise that RECs possess the requisite information, knowledge and finance to implement effective energy efficiency and conservation measures. Policy-makers therefore need to acknowledge the role of RECs as

important energy managers and seek to co-ordinate local energy policy accordingly.

Moreover, locally embedded utility companies have an overt interest in maintaining and developing the social, economic and environmental health of the regions they service and would clearly be effective partners in local economic regeneration strategies. Local and regional policy makers must begin to capitalise on this shared interest by monitoring levels of access to utility services and liasing with local utility companies on those strategies likely to draw local communities back onto infrastructure networks. Releasing information on the use of prepayment meters, monitoring of self-disconnection, encouraging the take up of telephone connections among low income households and the evaluation of utility token meter locations could all be usefully pursued.

Most urgently, new approaches to the regulation of splintered local, national and international utility networks must be developed. These regulatory frameworks must have two main priorities, the protection of vulnerable individuals and marginalised locales and the maximisation of environmental opportunities. The British regulatory system is currently blind to the social and spatial effects of the splintering process. Consumer safeguards are limited to a package of service quality indicators of little relevance to marginalised, low income customers. Motivated simply by the avoidance of the spectre of cross-subsidisation that characterised the nationalised era, regulatory bodies such as the Office of Electricity Regulation (OFFER) and the Office of Water Regulation (OFWAT) are refusing to accept responsibility for social objectives. Any notion of 'rights' to utility services, as exists in the United States with schemes such as the 'lifeline telephone', are absent in the United Kingdom. Explicit environmental regulation is similarly lacking. While safeguards on water quality and river sustainability exist in the water sector regulatory power fails to provide any mandatory requirement to conserve water. Equally, in the electricity sector energy conservation legislation is limited to modest standards of performance. This vacuum of social and environmental regulations must be urgently replaced by a stiffer regime. One which encourages the evolution of local and international utility networks on a technological and commercial pathway which maximises social and environmental benefits, rather than promoting utility poverty, uneven economic development and a doubtful environmental legacy. By developing a critical guide to this infrastructure revolution the future study of large technical systems has a significant role to play in this venture.

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