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Urban form, policy packaging and sustainable urban metabolism

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Abstract

Since the inception of modern urban planning in the early 20th century, numerous urban planning policies have been introduced that seek to steer urban form towards desired patterns. Some have explicitly focused on promoting energy efficient urban forms to reduce carbon emissions and contribute to sustainable urban metabolism.   Despite the proliferation of such policies, 'unsustainable' trends, such as urban sprawl and long distance car-based commuting, continue and in some cases are worsening. In this paper, we aim to explore the limited success of a number of influential urban planning policies in Europe and North America in trying to steer urban form towards a more sustainable path. Our aim is to identify their potential common shortcomings and suggest a number of principles which may help formulating more effective policy packages for sustainable urban metabolism.

Introduction: Metabolism and the city

The concept of metabolism emerged in the 19th century as a way of describing the exchange of matter between an organism and its environment. However, its application to cities, i.e. the idea of urban metabolism, is more recent and was first undertaken by Abel Wolman in his study of *The Metabolism of Cities* (Wolman, 1965). He modelled the metabolism of a hypothetical American city of one million people, quantified its inputs (such as water, food and fuel) and outputs (such as sewage, solid waste and air pollutants), and tracked their respective transformations and flows. Wolman's research was the first attempt to highlight system-wide impacts of consumption and waste generation in the urban environment. His work led to numerous empirical studies of the metabolisms of various cities in the 1970s. After about a decade of decline in such studies, interest in urban metabolism began to grow again in the late 1990s in line with the rise of environmental concerns and regulations. In the new wave of urban metabolic studies the most common approach is the bio-physical one with a focus on quantifying urban material and energy flows. There is a strong connection between this approach and the field of industrial ecology which seeks to optimize the "metabolism" of industrial systems through

symbiosis[1]. Both industrial and urban ecologists consider the city as a system, whose metabolism can be understood as "the sum total of the technical and socioeconomic processes that occur in cities, resulting in growth, production of energy, and elimination of waste" (Kennedy et al., 2007, p. 44). Back in the 1960s, Wolman identified three pressing metabolic challenges including: water supply management, sewage and waste disposal, and air pollution control. Today, climate change has led to a fourth and even more pressing challenge which is carbon emissions. Cities, through buildings, infrastructure and transport, produce 40 to 70 percent of global anthropogenic GHG emissions (Jones et al. 2009b). Thus, transition to low-carbon cities is a significant component of a more sustainable urban metabolism.

A significant aspect of built environment is urban form and density, i.e. the physical shape of the city and the connections between its different functions. The type, amount, density and location of various functions in the city and their interconnections influence the amount of transport-related energy use (Rode et al., 2014). Newman and Kenworthy (1999, 2015) have shown that per-capita transportation energy consumption decreases as population density increases. Although their findings have been disputed and research on the impact of population density on transport energy demand is inconclusive, researchers seem to agree that distance from the central business districts and other employment centres do lead to increases in energy use (Kennedy et al., 2007). Since the inception of modern urban planning in the early 20th century, numerous urban planning policies have been introduced that seek to steer urban form towards desired patterns. Some have explicitly focused on promoting more energy efficient patterns and hence reducing carbon emissions (EEA, 2006) and contributing to sustainable urban metabolism. Despite the proliferation of such policies, 'unsustainable' trends such as urban sprawl and long distance car-based commuting continue and in some cases are worsening. This begs the question of why these planning policies appear to fail. In this paper, we aim to examine a number of influential urban planning policies in Europe and North America which have tried to steer urban form towards a more sustainable path. Our aim is to identify their

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[1] This means that if the waste output from one industry becomes an input for another, it will provide co-benefits in terms of both economic cost and environmental prudence.

potential common shortcomings and suggest a number of principles for formulating more effective policy packages for sustainable urban metabolism. We draw on the research undertaken as part of a European FP7 project on *Sustainable Urban Metabolism for Europe* (SUME)[2].

The paper is structured under six sections. After this introduction, section two discusses multiple drivers of urban form; section three explores models of the (urban) development process; section four identifies typologies of policy interventions; section five analyses contemporary urban planning policies; and section six summarises our findings and presents conclusions.
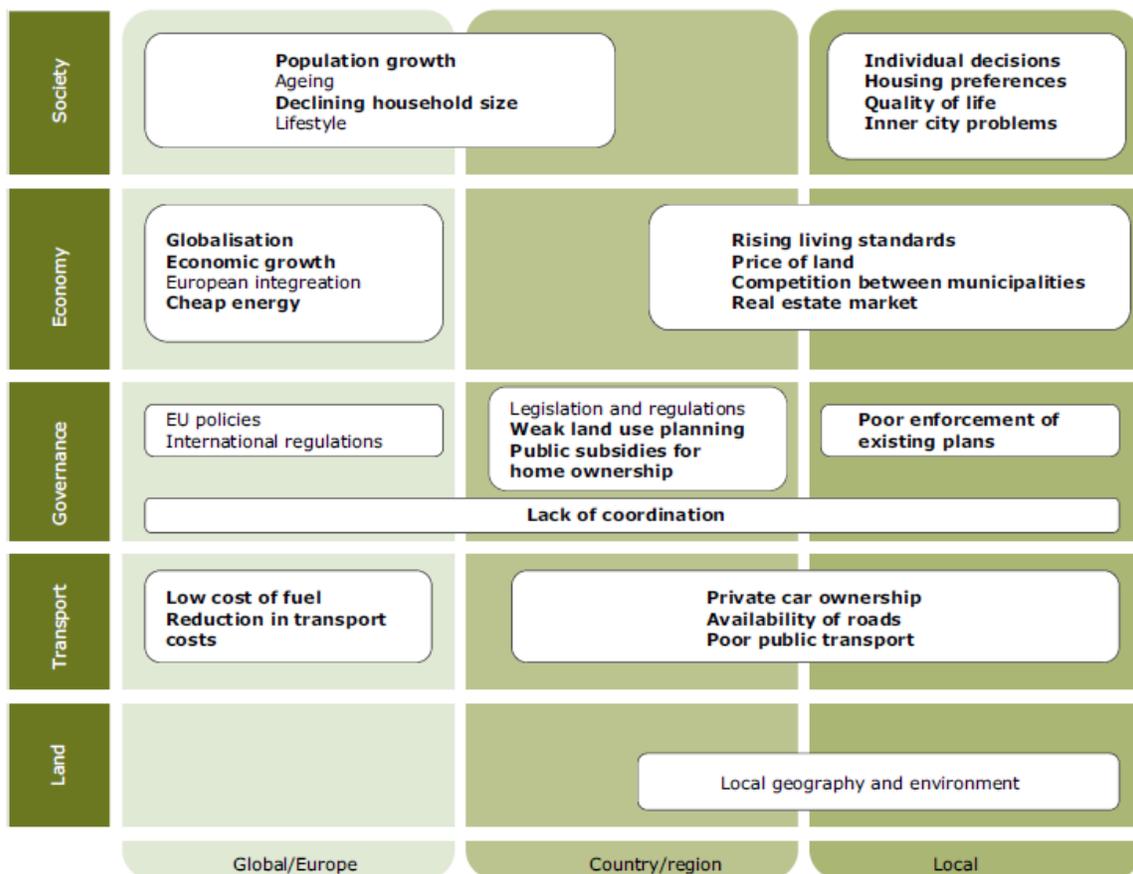
Drivers of urban form

As mentioned above, cities are responsible for a large amount of GHG emissions. However, there is a large degree of variation between different cities due to a complex interplay of their: urban form, building design and construction materials, people's use of the built environment, transport flows and modes, and the type of infrastructure. Whilst valid questions remain about self-selection, studies consistently find a relationship between urban form and transportation energy use (Cao et al., 2009). A comparison of Atlanta (in the US) with Barcelona (in Europe) helps illustrate this relationship (Bertaud and Richardson, 2004). Both cities have similar population of about 2.8 million, but Atlanta has 26 times the footprint of Barcelona partly because while Atlanta has a density of 6 people per hectares, Barcelona's density is 176 persons per hectare. In Atlanta the largest possible distance between two points in the built up areas is 137 kilometers (Km). In Barcelona it is 37 Km. Atlanta has a metro network of 74 Km long, but only 4% of its population live in 800 meters of a metro station. Barcelona has 99 Km of metro line and 60% of its populations live in 600 meters of a metro station. In Atlanta only 4.5% of trips are made by mass transit. In Barcelona, this is 30%. As a result, Barcelona's carbon

emission is 7 million tons, while Atlanta's is about 100 mt. The per capital emission in Atlanta is 400 metric tons while in Barcelona is about 35 tons. All these mean that density matters and so does the layout of buildings and transport modes. Despite this, the American model is being repeated in many emerging economies to the extent that it is estimated that a doubling of the developing world's urban population by 2030 will result in a tripling of their built-up areas, whereas a move towards cities that are more public transport friendly could reduce greenhouse gas emissions by 20 to 50 % (IPCC, 2014).

The drives of urban form and density are multiple and complex. A report by the European Environment Agency identified five main drivers of urban transformation including: society, economy, governance, transport and land; with each having a different level of influence at different global, national and local scales (ESPON, 2010) as shown in Figure 1.

Figure 1 – Main drivers of current urban sprawl in Europe

Source: ESPON (2010:22)

This is one of a number of attempts to identify the main drivers of urban sprawl, but we would argue it is both partial (omitting, for example, the influence of technology on facilitating urban sprawl through home working, etc.) and insufficiently cognisant of the interrelationships between drivers and between the different scales it considers. For us, it is for instance hard to separate "individual decisions" from "low cost of fuel" from "globalisation" in the way that this schematic does. This is one reason that, as discussed in the next section, we developed an alternative model of the development process.
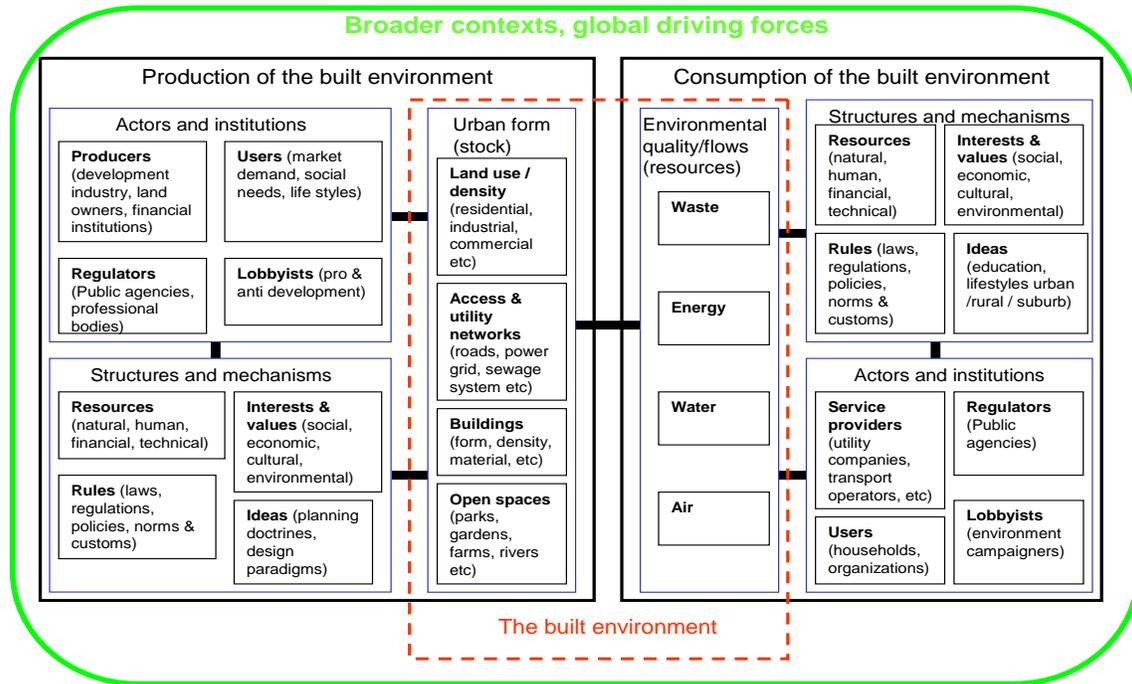
Models of the development process

There is now a reasonably long history of attempts to model the development process, i.e. the process by which built development happens, the key actors involved in that process, what motivates those actors and what structuring forces drive and shape the process (for reviews of these models see Barrett et al., 1978; Gore & Nicholson 1991; Healey, 1991, 1992). The cited reviews identify three broad types of model: agency-based, focusing on actors in the development process; structure-based, focusing on the larger-scale dynamics of the development process; and institutional-based, linking structure and agency together. A fuller review of these models can be found in Davoudi et al., 2009. Whilst all have advantages and disadvantages, we have identified a set of common flaws, critical in terms of the urban metabolism approach. These flaws are: firstly, the omission of key factors of the development process such as technology or skills (much like Figure 1); secondly the lack of a specific environmental or socio-environmental consideration; thirdly, failure to explicitly relate the development process to urban form; and fourthly, a lack of a global perspective which limit transferability.

To address these flaws we have developed what we call a 'socio-ecological model' of the urban development process based on a more nuanced set of drivers relating to both production and consumption of the built environment. These suggest that a particular urban form (stock) and the uses of urban flows (such as energy and water) are the outcome of a complex interplay between: actors, institutions, structures and mechanisms. Together they shape the development process in each locality (see Figure 2). Within this model and cutting across the production and consumption of the built environment, *actors and institutions* include: producers, regulators, users and campaign groups, all of whom have the potential to influence the development process albeit with varying degree of power and leverage. *Landowners*, for example, can determine land supply and control what gets built where and when by using their access to property rights (Adams et al., 2000). *Developers* can determine what gets built with what materials and in what form or shape by using their investment power (Harvey and Jowsey, 2004). Both actors can be regulated and steered by *government agencies* which can use their democratic power of public representation to

enable or constrain the property market (Healey et al., 1988). *Users and consumers*, on the other hand, can choose where they want to live, in what type of house and how they want to use the flow of resources, by adopting a particular lifestyle and using their purchasing power (Phe and Wakely, 2000; Davoudi et al, 2014). *Lobbyists and campaign groups* can influence people's and politicians' attitudes to a particular type of development by using their power of advocacy (Sturzaker, 2010). Clearly, the process is contested and does not take place in a political vacuum or within an evenly-distributed power relation (Vigar et al., 2000). This means that the outcome depends highly on the balance of power between these actors and institutions.

The development process is also shaped by a number of *structuring forces* which operate across the production and consumption of the built environment. Some of these structuring forces are more tangible such as *formal rules and resources* (Zweigert et al., 1987)*, others are less tangible such as *societal values* (Davoudi & Stead, 2002) and people's *lifestyle choices* (Filion et al, 1999). Technological innovations, for example, have had a major impact on urban form. The invention of new transport technologies along with cheap energy and information and communication technologies have facilitated the sprawling urban form of many cities, while the invention of the elevator and new construction technologies have enabled high density, high rise development, which evidence suggests are more sustainable against a number of criteria (Rode et al., 2014). What is less discussed in the literature is the influence of the less tangible issues on urban form, such as ideas and planning doctrines (such as the Green Belt in the UK and the Green Heart in the Netherlands) and cultural norms and values. For example, for English people the ability to live in the countryside is an indication of social status (Davoudi & Stead, 2002) in the same way as having a summer house is for Finnish and Swedish people (Gallent et al., 2003). Although there is widespread agreement among practitioners on the need to pursue the principles of sustainable urban metabolism, there is much less awareness of the complexity and nuance of the factors that drive the development process, shape urban form and, in some cases, lead to urban sprawl. We believe our model reflects this complexity whilst acknowledging the risk of over-simplification and codification.

Figure 2 – Socio-ecological model of urban development process

Broader contexts, global driving forces

Production of the built environment

Actors and institutions

Producers (development industry, land owners, financial institutions)

Users (market demand, social needs, life styles)

Regulators (Public agencies, professional bodies)

Lobbyists (pro & anti development)

Structures and mechanisms

Resources (natural, human, financial, technical)

Interests & values (social, economic, cultural, environmental)

Rules (laws, regulations, policies, norms & customs)

Ideas (planning doctrines, design paradigms)

Urban form (stock)

Land use / density (residential, industrial, commercial etc)

Access & utility networks (roads, power grid, sewage system etc)

Buildings (form, density, material, etc)

Open spaces (parks, gardens, farms, rivers etc)

Environmental quality/flows (resources)

Waste

Energy

Water

Air

Consumption of the built environment

Structures and mechanisms

Resources (natural, human, financial, technical)

Interests & values (social, economic, cultural, environmental)

Rules (laws, regulations, policies, norms & customs)

Ideas (education, lifestyles urban /rural / suburb)

Actors and institutions

Service providers (utility companies, transport operators, etc)

Regulators (Public agencies)

Users (households, organizations)

Lobbyists (environment campaigners)

The built environment

Source: Davoudi et al., 2009

In the SUME project we tested this model through exploring the development process in a number of European city-regions, including Oporto, Stockholm, Newcastle upon Tyne and Vienna (see Davoudi et al., 2011 for a full report). One of the relationships we tested was the interface between *users' preference* and *planning regulation*, and the effect this had on the urban form. These comprise two critical factors: one is the state-market relationship and the other is user preference (see Figure 3).

Figure 3 – Interface between users' preference, planning regulation and alternative urban forms
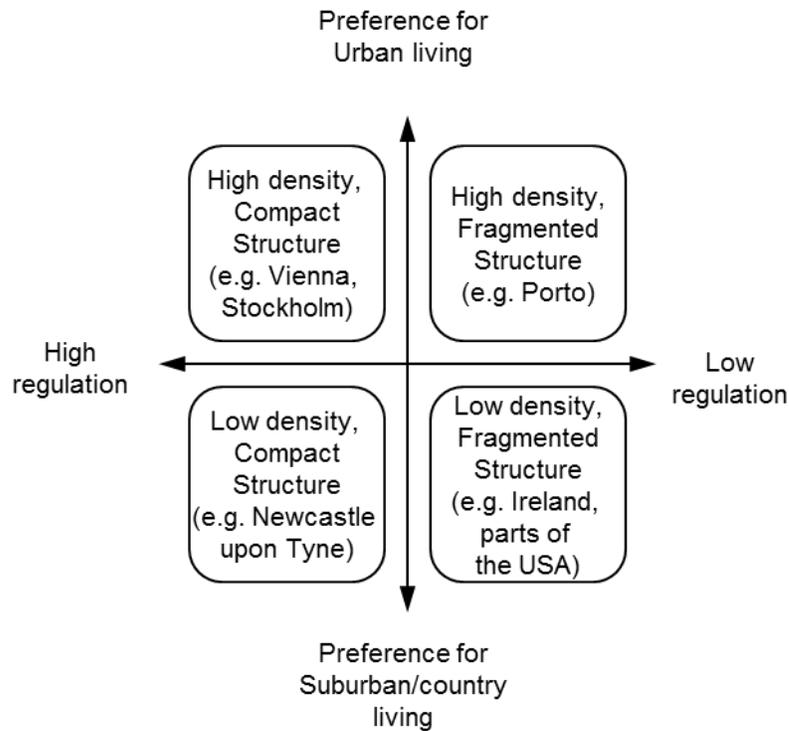
Source: adapted from Davoudi et al. (2011)

One of the critical factors which can sway the development process and lead to the highly variable patterns of urban form is the interaction between the *state* and the *market* (Barlow & Duncan, 1994). In some places (such as Stockholm, Sweden), the state (i.e. the public sector at national, state, regional or local level) can exert significant influence over urban development by, for example, taking a lead in assembling land, delivering building programmes, and/or making use of regulatory systems (such as urban planning) to

determine or guide development towards particular directions (Hårsman & Olsson, 2003; Davoudi et al., 2011). In other places (such as Newcastle-upon-Tyne, UK) the private sector may be the dominant player and the development process is driven by the dynamics of the free market and in response to perceived consumers' demand (Cullingworth et al., 2015). Another critical factor is the deep-rooted social and cultural preferences for urban or rural living (Gallent et al., 2003). The juxtaposition of these two sets of factors results in very different urban forms in different places. Therefore, in a country with strong planning regulation (horizontal axis in Figure 3) and a social preference for urban living (vertical axis in Figure 3), such as Austria, one can expect to see thriving high density, compact cities. On the contrary, in countries with weak planning regulation and a social preference for living in the countryside, such as Ireland and the USA, a low density, fragmented urban sprawl can be expected.

The above discussions suggest that in order to change a given historical urban form requires changes in a number of directions including: regulatory systems, development finance and social and cultural practices. The example in Figure 3 shows just two variables, whilst Figure 2 indicates the breadth of variables that can come into play. However, as we will discuss in the following section, this wide-ranging approach is rarely adopted. Indeed, 'the majority of the European planning systems […] have not yet produced specific and consistent regulatory frameworks' (Jones et al., 2009a, p. II), let alone gone beyond this.

Typologies of urban policy interventions

There are a number of typologies of how governments intervene in the free market through policies. An early attempt was by Lichfield and Darin-Drabkin (1980) who identified three ways for governments to intervene in the development process. These include: direct control over development, fiscal control over urban development and general influence over development. Similarly, Tiesdell and Allmendinger (2005) argue that governments' intervention can have four aims including: market-shaping, market regulation, market stimulation and capacity building. Both of these typologies are based on the urban

development markets in the UK where there are very little direct provisions by the public sector. Another typology by Rydin (2010) identifies a four-way typology of the role of government's intervention including: information provision and persuasion, financial incentivisation, collaborative action, and regulation and planning gain. While this recognises the role of 'collaborative activity', and goes beyond the UK, it neglects the role of the state in direct provision of for example housing, perhaps because it takes a predominantly Anglo-American focus. In the SUME project, we looked at these issues across Europe to capture the diversity of approaches to development (ESPON, 2010) and, hence, added a fifth type of intervention to reflect the opportunity for the state to take a more active role in urban development – something which remains a powerful factor in other countries, if not the UK. Our five-fold typology consists of:

1. Planning and building regulation
2. Fiscal and non-fiscal incentivisation
3. Direct provision by public and/or voluntary sectors
4. Education and awareness-raising
5. Promotion of behavioral change

Formulated in an integrated and coordinated way, these have the potential to create an effective policy package aimed at energy efficient urban metabolism. But does this happen in practice?

We draw on this five-fold typology of policy aims to understand how some of the contemporary urban planning policies aimed at changing/shaping urban form in more "sustainable" directions are intended to work and why they might not have been entirely effective in reducing sprawl and transportation energy demand.

Analysis of contemporary urban planning policies

What is meant by a sustainable urban form can be summarized in three key principles: development at higher densities, concentration of development along public transport

corridors, and creation of a mixture of land uses. These are seen by many commentators as the factors leading to a reduction in the need, and hence the tendency, to travel by private car (Newman & Kenworthy, 1999 being perhaps a keystone text in this regard) and hence energy use. As mentioned above, numerous urban policies have aimed explicitly or implicitly to deliver these principles. While these policies range widely in terms of their aims, instruments, contexts and targeted actors, Jabareen (2006, p. 39) grouped them into four main models: Neotraditional development, compact city, urban containment, and eco-city. This is clearly just one possible grouping, but it is helpful as a way of attempting to categorise what urban policies are trying to achieve, as in some cases the aims of such policies can be opaque, beyond perhaps achieving "sustainable development". Using Jabareen's types as our guide, we have identified and reviewed a sample of each type in Europe and USA to examine their effectiveness and potential shortcomings. The reviewed urban policies are from the UK, the USA (with highly variable approaches between different states yet with Maryland generally agreed to be towards the forefront of best practice), Denmark (specifically Copenhagen), Austria (specifically Vienna), Germany (specifically Munich), The Netherlands, Sweden (specifically Stockholm) and Norway (specifically Oslo). These policies comprise some of the cases used in the SUME project (Vienna, Stockholm and the UK) with others identified in the literature (see below for specific references). Table 1 illustrates how the urban policies that we have reviewed fit within Jabareen's models. As Jabareen makes clear, there are overlaps between the four models, and this is exemplified by our review – whilst some policy packages fit neatly within one model (and in some cases share a name with a model, though this is rarely an "official" name, rather the name ascribed to the policies by commentators), others cut across two, three or even four models of sustainable urban form – which might in itself suggest a lack of clarity about what the policy is trying to do. Table 1 indicates what we believe to be the main model of urban form the reviewed policies seek to deliver.

Table 1 – Models of urban form and examples of urban planning policies

		Jabareen's models of urban form			
Location	Reviewed urban	Neotraditional	Compact	Urban	Eco-

	policies	development	city	containment	city
UK	Urban renaissance	✓			
USA	Transit Oriented Development	✓			
Netherlands	Compact city		✓		
UK	Urban containment			✓	
Copenhagen, Denmark	"Five fingers"			✓	
Maryland, USA	Priority Funding Areas			✓	
Netherlands	ABC			✓	
UK	Eco-towns				✓
Vienna, Austria	No specific title		✓	✓	
Stockholm, Sweden	No specific title		✓	✓	
USA	Smart growth*	✓	✓	✓	✓

* Smart growth, rather than being a defined policy or package of policies, is more of a label for a general approach to urban planning and development

As with any policy review of this type, there is an element of subjectivity to this analysis, partly due to a seeming reluctance on the part of policy-makers to explicitly specify the aims of their policies. This is perhaps unsurprising because, as argued by Hogwood and Gunn (1984), failure to define the aims of a policy makes it harder for others to assess whether the policy has succeeded and hence hold the policy makers to account! What does, however, unify these policies is that they represent attempts to guide urban development in more 'sustainable' directions. Another common factor is that none can be regarded as being an unqualified success because in all of the cities/countries which are the subject of these policies unsustainable practices in the form of long-distance commuting and urban sprawl continue to occur (EEA. 2006; Richardson, & Bae, 2004). It is, therefore, useful to analyse in more detail the approaches taken to identify any common

reasons for success and/or failure, in order to contribute to the development of more effective policy packages that contribute to energy efficient urban metabolism. The following section is organised according to Jabareen's models of urban forms. For each model we have reviewed one or more examples representing that model and drawing on our five-fold policy typology (1. Planning and building regulation; 2. Fiscal and non-fiscal incentivisation; 3. Direct provision by public and/or voluntary sectors; 4. Education and awareness-raising; 5. Promotion of behavioral change) examined the extent to which these examples have used all five policy types to generate an effective policy package.

Neotraditional development model

Drawing on an analysis of literature, Jabareen (2006, p. 43) suggests that, 'the ideal neotraditional town would be self-contained, tightly clustered, walkable, and patterned on the American small town of pre–World War II'. In the UK, the *urban renaissance* policy promoted from 2000 derived, to an extent, from similar motivations, but focussed on urban regeneration in order 'to bring people back into our cities, towns and urban neighbourhoods' (Urban Task Force, 1999). This mission statement implies a policy focus on education and awareness raising (type 4 of our five-fold policy typology) as well as promotion of behavioral change (type 5). In practice, however, policies were generally negative in nature, targeted at developers and using planning regulation to limit the amount of development outside urban areas. Key measures used were new targets in relation to density and the proportion of homes built on previously developed land (DCLG, 2006). So, rather than pulling people back to urban areas, as the policy rhetoric suggested, policies focused on pushing them out of other areas. This dissonance is a recurring theme throughout this discussion, as is the (perhaps predictable) failure of policy to achieve its aims.

Transit Oriented Development (TOD) is identified by Jabareen as another form of neotraditional development with three core elements: 'mixed-use development, development that is close to and well served by transit, and development that is conducive to transit riding' (Jabareen, 2006, p. 44). It has been adopted in practice in various cities

across North America, including Calgary, San Francisco and Portland. The emphasis in TOD has again often been on planning regulation policies (type 1). Although this limited scope has been criticised (Goodwill & Hendricks, 2002) the TOD concept retains strong currency in the USA. However, at the time of writing, it had not been in place long enough for its meaningful examination.

Compact city model

As the name implies, the core idea of the compact city model is compactness and hence higher density built form. Those promoting this model argue 'that in more compact cities, travel distances are reduced (thus lessening fuel emissions), rural land is saved from development, local facilities are supported, and local areas become more autonomous' (Jabareen, 2006, p. 46). Policy makers in the Netherlands have been promoting the compact city model for over forty years (Dieleman et al., 1999) – albeit initially under the 'concentrated deconcentration' philosophy which was later became known as polycentricity (Davoudi, 2003). The main policy used has been planning regulations (type 1 of our five-fold typology) aimed at limiting the growth of urban areas. This, along with high levels of investment for regeneration (type 3), has been cited as being 'instrumental in renewing population growth in the central cities and (re)creating a lively pedestrian setting in central parts of the cities' (van der Burg & Dieleman, 2004, p. 111). However, the policy approach is not seen as being entirely successful – van der Burg and Dieleman (2004) note that there are ongoing shortages of housing due to the inflexibility of the planning system, and that mobility patterns have not changed to the extent that was anticipated – despite their reputation for cycle and public transport use, the motorways of the Netherlands are frequently subject to heavy traffic jams.

Vienna is another example where compact city policies have been centrally used in urban planning in recent decades. We consider Vienna's approach (along with that of Stockholm) as being amalgams of the compact city and urban containment approaches (see Table 1) given that in these two cities the two approaches seem to operate hand in hand. The Vienna example is one where there is more policy integration than usual. There is

evidence of planning regulatory policies (type 1) being used in conjunction with investment policies (type 3) and fiscal incentivisation (type 2) in the form of subsidies to housing development in more 'sustainable' locations. Vienna has had success with locating development near to public transport corridors, with 96% of the population being within 500m of a public transport route (UITP, 2011). While densities were described as "only average" by the SUME project partners who were based there, what is seen as average in Vienna is considered high in places such as the UK or USA. In Stockholm, a similar mixture of planning regulatory policies (type 1), fiscal incentives (type 2) and direct provision (type 3) are used (Hårsman & Olsson, 2003), but there can be a lack of coordination between policy sectors (Öresjö et al., 2004).

Urban containment model

'At its heart, urban containment prevents the outward expansion of the urban field and forces the development market to look inward' (Jabareen, 2006, p. 44). Jabareen notes that policy makers in the USA tried to introduce urban containment policies as a result of the high proportion of growth in suburban areas in the 1970s and 1980s. In other countries, however, urban containment has a much longer history. For example, it has been one of the post-war planning orthodoxies in England (Hall et al., 1973) with an almost exclusive reliance on planning regulation policies (type 1 of our typology), with the Green Belt principal amongst these (Sturzaker & Mell, 2016). Despite this, it is not uncommon for other types of policy (principally type 2: fiscal incentivisations) adopted by the UK Government to act in contradiction to the planning policies. One example is the negative financial incentives for private developers which have been generated due to existence of a higher rate of tax levied on renovating and retrofitting buildings than on new building on greenfield land (Adams et al., 2000). Similarly, there has been a general policy of keeping the cost of private car ownership low and more recently easing restrictions on car parking in urban areas, a policy mobilised in the name of ending the 'war on motorists' (DCLG, 2011). These conflicting policies illustrate what has been observed elsewhere as the intensely political nature of planning (Randolph, 2004). Working sometimes diametrically

in opposition to each other they greatly reduce the effectiveness of urban policies aimed at energy efficient urban forms.

The ABC policy in the Netherlands is another example which can be broadly defined as urban containment. This was undermined less by conflicting policy from the same tier of government and more by conflicts between the national government policy and the implementation of that policy by local governments. The ABC policy was intended to focus development in three types of location with different transport characteristics (A, B, C): '**A** locations were close to main railway stations; **B** locations were situated in development nodes outside the larger CBDs and the centres of smaller urban settlements, were reasonably well connected to public transport, and readily accessible by car; and, **C** locations had a good motorway access – typical examples were business zones in the urban fringes or alongside motorways' (Bogaerts et al., 2007, p. 33). The policy ran from 1990 to 2004 and features the use of planning regulation (type 1) in conjunction with investment in public transport (type 3). The policy was undermined by the conflict mentioned above, because '[l]ocal government authorities often gave higher priority to attracting new employment (read: new jobs and income) than to strict adherence to locational rules' (ibid.) – i.e. every municipality wanted a business park irrespective of where it was located!

An example of a well-known and more effective urban containment approach is Copenhagen in Denmark. The so-called *Five Fingers* urban planning approach, originated in the unofficial 'Fingerplan' of 1947, has now become part of the mainstream planning doctrine in Copenhagen. The aim of the Five Fingers approach is to concentre urban growth in slender 'fingers' so that the green wedges between them maintain proximity to green space. It is also to encourage public transport use (public transport lines being developed along the fingers). So, the state's investment in public transport (type 3 of our typology) has been aligned with strong planning controls (type 1) and, it seems, public support for the concept of the 'finger plan' (type 4). Whilst the higher than expected rate of population growth has resulted in the fingers 'bulging' out and commuting is occurring

between the fingers (Vejre et al., 2007), the Five Fingers approach is one of the more successful policies we have reviewed.

The dominant measure policy measure used in the above examples are planning and building regulations (type 1 of our typology). An example of an urban containment approach which was led by fiscal incentivisation (type 2) is that of the Priority Funding Areas (PFAs) in Maryland, USA. Introduced in 1997, PFAs are what we might call macro-level incentivisation. State funding for infrastructure spending are allocated to specific geographical areas, considered as sustainable locations, to incentivise development in those areas. The logic behind this approach is that the state government pays much of the cost of infrastructure provision so that the availability of infrastructure can shape the direction of urban growth. However, as noted by Lewis et al. (2009, p. 459), 'the voluminous literature on the effect of infrastructure investment is less than definitive'. This casts doubt on the logic behind the policy. Furthermore, a lack of integration between PFAs and planning policies, along with insufficient monitoring by the state government, contributed to the failure of PFAs to direct development to defined areas. This is evident by the rising proportion of land developed outside the PFA areas between 1990 and 2004 (Lewis et al., 2009). Of course, as Lewis et al. observe, the pattern of development may have been even less sustainable without the policy in place, but PFAs cannot on these terms be considered to be a success.

Eco-city model

It is harder to identify specific examples of policy packages that seek to deliver Jabareen's eco-city model of urban form[3], largely due the slightly ill-defined nature of the model: '[T]he eco-city is an umbrella metaphor that encompasses a wide-range of urban-ecological proposals that aim to achieve urban sustainability' . But Jabareen goes on to state that the model is one which focuses on the management of the city rather than necessarily a particular urban form. In this regard the 'eco-town' policy which operated in

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[3] It should be noted that at the time of the study very little was known about the rising number of eco-cities particularly in China.

the UK between 2007 and 2010 is an interesting example. It promoted 'small new towns of at least 5-20,000 homes' (DCLG, 2007, p. 4) and follows the tradition of Ebenezer Howard's Garden Cities and new towns, built in several phases in the UK from the start of the twentieth century onwards (TCPA, 2011). The eco-town policy intended to bring forward locally-led new settlements, and the Government's guidance seems to have been written deliberately to avoid specifying an ideal urban form, other than that they should feature 'the best new design and architecture' (DCLG, 2007, p. 4). The eco-town policy was one that was led by a permissive rather than regulatory planning approach (type 1 in our policy typology), and the use of supportive rhetoric (types 4 or 5). The policy generated a large amount of opposition and was perceived by those objecting to it as 'unpopular and undemocratic' (Clifton, 2008). It was also strongly associated with the Labour Government so following the 2010 election the Conservative-Liberal Democrat coalition Government abandoned the policy with only one eco-town having received planning permission (Barclay, 2011). In 2014,t Government began promoting what it called "Locally-led garden villages, towns and cities" (DCLG, 2014), indicating a move away from a nationally prescribed model to a locally-led one. At the time of writing very few have come forward.

The suite of policies which has been labelled 'Smart Growth' in the USA is perhaps another example of the eco-cities approach – or, at least, is similarly ill-defined. As noted above, because urban planning regulation is devolved to the state and local level in the USA, there is no common approach in delivering more sustainable urban form. Knaap and Talen (2005) in a review of Smart Growth policies found that they included attempts to, *inter alia,* broaden housing choice, encourage walking, mix land uses, and providing a variety of transport choices. These varied aims, and the similarly diverse range of policies used to achieve them, are due to the 'inherently flexible' nature of the Smart Growth concept (Howell-Moroney, 2008). There have been criticisms at this lack of specificity and the fact that many states have adopted a piecemeal approach to policy development. Although the piecemeal approaches are 'more practical and politically realistic' (APA & Smart Growth Network, 2002, p. 8), they are less effective than a comprehensive policy might be and fail to deliver all the benefits of Smart Growth (Howell-Moroney, 2008).

Summary of analysis of urban form and planning policies

The above review suggests that across Jabareen's four models of urban form, there is a tendency on the part of policy makers to choose only a limited range of policies from our five-fold policy typology. Table 2 illustrates the narrowness of policies adopted.

Table 2 – Mapping of policies types onto existing policy packages

Location	Reviewed urban policies	Jabareen's models of urban form				Policy types				
		Neotraditional development	Compact city	Urban containment	Eco-city	Planning and building regulation	Fiscal and non-fiscal incentivisation	Direct provision by public and/or voluntary sectors	Education and awareness-raising	Promotion of behavioral change
UK	Urban renaissance	✓				✓			X	X
USA	Transit Oriented Development	✓				✓				
Netherlands	Compact city		✓			✓		✓		
UK	Urban containment			✓		✓	X X			
Copenhagen, Denmark	"Five fingers"			✓		✓		✓	✓	
Maryland, USA	Priority Funding Areas			✓		X	✓			
Netherlands	ABC			✓		✓		✓ X		
UK	Eco-towns				✓				✓	✓
Vienna, Austria	No specific title		✓	✓		✓	✓	✓		
Stockholm, Sweden	No specific title		✓	✓		✓	✓	✓		
USA	Smart growth*	✓	✓	✓	✓	✓				✓

Key: ✓ indicates policies which were actually used, X indicates policies that the policy rhetoric suggested might be used, XX indicates where national policies were used in contradiction to other policies, and ✓X indicates a conflict between different tiers within the same policy type. See text for more details.

As Table 2 illustrates, most of the examples identified make use of our first type of policy, planning and building regulation. Some, such as the urban containment approach in the UK, are almost exclusively reliant on these. Our second type, incentivisation (fiscal and non-fiscal) policies are rarer. Examples here range from the micro to the macro-level, including the Priority Funding Areas programme in Maryland, USA. Our third type, direct provision by public / voluntary sector such as provision of social / affordable housing is more common in countries such as Sweden and the Netherlands than in the UK and USA. The Netherlands, for example, still sees large scale housing development by the government, whereas in the UK local government which used to be the main provider of affordable housing hardly build any new houses at all. With regard to our fourth type, education and awareness-raising, we can consider these for both producers and users. As regards the former, examples include promoting higher sustainability standards for built environment professions through education and regulation of the professional codes of practice. As regards the latter, examples include public campaign for sustainable living and the use of media which although is not enough in changing attitude and behaviour can provide a useful and necessary input into the policy mix. While the former is more common, we found little evidence of the latter in our study. This appears to be a major flaw in the policies adopted in different countries. Finally, our fifth type of policy, behavioural change, would recognise that the context for policy implementation is central to their success. Attempts to provide a more positive context through capacity-building or other means appear to be neglected, with a focus often exclusively on the policy itself, rather than its broader context and those who are affected by it.

These findings mirror those of Adams et al. (2009), in their review of property policy adopted by the Scottish Government. They show that policies used in various European countries and aimed at sustainable urban form put the emphasis on regulating the market with less attention being paid to incentivising sustainable practices in the development process or building capacity for built environment professions to pursue such practices. At the same time, our review shows that policies are overwhelmingly targeted at just one group of (albeit very diverse) actors – developers and landowners. Without this group, of

course, development cannot occur, but conversely, without end-users there would be no development, so it is perhaps surprising that there is such a lack of policies targeting the end users. When such policies exist, they often target the behaviour of users indirectly – for example congestion charging, which seeks to change the method by which households and businesses travel around an urban area, but only indirectly targets their locational preferences. Again, these findings echo those of Adams et al (2009) in the context of Scotland, who identified a strong focus on developers as the target group of policies, with very little consideration of user or investment activity.

Conclusions

Transition to low carbon cities is a key component of sustainable urban metabolism and that cannot be achieved without major rethinking of urban form. Since its birth in the early 20th century, modern urban policies have attempted to promote energy efficient patterns yet unsustainable trends appear to persist. In this paper, we reviewed some of the more prominent and influential policies which represent a diversity of aims, instruments and contexts. While they have achieved certain goals, none has been considered as an unqualified success. The Copenhagen's Finger Plan - which is one of the best known policy packages of this type- has succeeded in directing the development along the 'fingers' but, has not been able to prevent the fingers from being widened, the green wedges from being narrowed and the commuting from taking place between them. In the Netherlands, while the compact city approach is considered as one of the most successful policies, commuting (often by car) between major urban areas remains high. In the UK, the drive to concentrate development in urban areas continues but there remains a strong demand for suburban and rural living and insufficient demand for city centre apartments, outside London. While the Green Belt policy has broadly contained urban sprawl, in places where development pressure is high, such as the South East of England, it has also led to the leapfrogging of the development beyond the Belt and hence increased commuting distances. These examples reflect experience worldwide, where it has been suggested that urban densities may be failing in many contexts, despite the benefits of densification discussed above, and indeed policies to limit sprawl (Angel, 2011).

One possible explanation for limited success of these policies is that they often work in isolation from other policy areas. What seems to be missing is the formulation of complementary policy packages which work in harmony within a coordinated institutional framework, targeted at all relevant actors and with the clear aim of moving towards a more sustainable urban metabolism. Three key recommendations have arisen from our work which if implemented can increase the effectiveness of policy packages aimed at delivering a more sustainable urban form and hence a more energy efficient urban metabolism. These are as follows:

1.   Policies should be packaged to fit the purpose

Achieving more sustainable urban metabolism requires packaging together more than one of the five policy types (regulation, incentivisation, direct provisions, education and awareness raising, and behavioural change). The latter three, which are often not part of urban policies, are particularly important. Neglecting them is often due to a potentially naïve understanding of how the development process works. The evidence is that policies which focus on regulatory tools only, have less chance of being successful. The benefits of policy integration can be seen in Munich, where in the 1960s town planning was replaced by "urban development planning" which provided guidelines for all the responsibilities of the municipal governments, including education and cultural issues. An integrated urban development plan was developed, supported by an independent department of the city government which coordinates municipal planning activities and strengthen stakeholder and research involvement (Theirstein & Reiss-Schmidt, 2008). This approach has been commended by the European Environment Agency (EEA, 2006), and can be seen as a rare example of a policy which takes account of a great deal of the complexity of the development process (illustrated in Figure 2 above), leading to a more sustainable urban metabolism overall.

2.   Policies should target all relevant actors

Similarly, if urban development policies are to be effective, they need to target actors other than landowners or developers. The approach adopted in many countries appears to be based on the notion of "if we build it, they will come" – by regulating/incentivising developers to build in particular locations, policy makers assume that end-users will be happy to live in those areas, and will live "more sustainably". In many countries, households, particularly families, are not necessarily behaving according to the wishes of policy makers. They are *strategically disobedient*, as they do not organise their lives as the planning system hopes they will (Shorten, 2005) – there may be ongoing use of the private car despite the presence of jobs and services within easy reach on foot or public transport. Only if policies target end-users can such trends be challenged and cities become more sustainable in urban metabolism terms, as opposed to patterns of urban form perhaps *appearing* sustainable but in practice being unsustainable.

3.   Policies should address users' behaviours and social practices

Davoudi et al. (2014) provide a review of the literature on behavioural change in relation to energy consumption. Drawing on a wide range of literature particularly Tim Jackson (2005) and Anthony Giddens (1984) they argue that people's broader behaviour is the result of a complex set of interactions between their attitude and intentions, their habitual responses, and situational constraints and conditions under which they operate. Their intentions are then influenced by social, normative, and affective factors as well as rational deliberations. Jackson (2005) suggests that people's consumption (including of the built environment) is based on a set of social practices which are influenced by both their lifestyle choices and by the institutions and structures of society, including those which determine the production of the built environment. For policy to be effective, it needs to be developed with an understanding of the social context of unsustainable behaviour. The vast majority (possibly all) of policies reviewed in this paper focus on the (admittedly easier to affect) part of the equation – what Jackson calls 'rules and resources'. The 'softer' set of influences, 'discursive and practical consciousness', are not targeted. So

only half (at best) of the factors which affect behaviour are addressed by policies, contributing to the *strategic disobedience* identified by Shorten (2005). It seems, then, that policy makers need to consider the social context of unsustainable behaviour, and conceive policies to address it.

These three recommendations are informed by our work on the SUME project which aimed to "Contribute to the reduction of space, energy and material consumption of urban regions through strategies of urban restructuring and urban planning, founded on a comprehensive metabolic analysis/modelling" (Davoudi et al., 2009). In conclusion, the analyses in the SUME project and this paper clearly demonstrate that existing attempts to make cities more "sustainable" by attempting to reshape urban form have had very limited success. Their failures are often due to a lack of understanding of the complexity of the development process in terms of both production and consumption which itself is related to a lack of understanding of how cities function. We suggest that an approach grounded in urban metabolism as a theoretical backdrop, and utilising a fuller understanding of development through a socio-ecological model of the urban development process, similar to that shown in Figure 2, is an essential step towards cities that can function in a more sustainable way.

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