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Spatial, mobility and energy planning: a cross-sectorial and actor-relational approach

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1. Introduction

The complex reciprocal influences of the spatial pattern of human activities and mobility patterns on energy consumption have been the subject of a great deal of theoretical and policy research: the nature and availability of energy resources have always influenced spatial distribution of activities and mobility behavior, and vice versa. At the moment many questions arise with regard to the conditional (f)actors of this triple interrelation, because of some structural changes occurring such as the depletion of fossil fuels and the climate change, the transition towards more sustainable and equitable transport systems and the on-going economic crisis. Another important changing condition is the shift from a high centralized and fossil fuel based energy system to a more decentralized and renewable one which give the spatial dimension a crucial role in the allocation and utilisation of energy sources. Some cases of integrated spatial and energy policies are developed within the “Energy landscapes” approach (Normann and de Roo, 2011) and include for example energy domestic production or (self-) governance “community energy” initiatives (Avelino et al. 2014). Policies that integrate mobility and energy sectors regards solutions for the optimization of energy in the transport sector and include for example energy saving technologies for the automotive industry or tools to support transport systems users reducing their energy footprint (Gautama et al. 2014). Moreover, even land-use and transport integration is often evocated as a solution towards sustainability. Nevertheless most of the current energy policies are not integrating the space and the mobility fields at the same time or are putting these into practice by sectorial measures. Because of these separated knowledge and research domains, in planning practice the multi domains and cross-sectorial dimension of the issue is often neglected.

With a view to the shifting social circumstances, this paper reflects on how to integrate the spatial-mobility energy domains in the energy transition, from the viewpoint of the planner. Indeed, as stated in other studies (Stoeglehner et al, 2011), we argue that a radical shift in energy provision can only be achieved if its spatial dimensions are taken into consideration. To give answer to this question, this study presents a framework of approaches and applications developed in the last 15 years, based on a literature review and contributing to understand how the crossovers between the domains of spatial, mobility and energy planning have been faced and have recently evolved, in order to identify intersecting issues and not yet covered themes. The research demonstrates that only in few and more recent studies and applications the full integration of the three domains is covered, with not still an integrated perspective.

Starting from this, the study argues that to make a shift towards integration between space, mobility and energy a new planning approach is needed. Planning should address the multiplicity and fuzziness of different actions in time and space concerning discursive, collaborative, informal and post-policy planning, as well as relational geography, multi-planar, non-linear and actor-relational approaches (Boelens, 2010; Boelens and de Roo, 2014). In other word, the new planning attitude should be post structural, co-evolutionary, actor relational, situational and departing from specific transitions and ambitions. The interpretation of the space, mobility and energy domains should be seen as an arena's of changing (f)actors-networks in order to understand and create new links beyond the existing borders.

2. Crossovers between spatial, mobility and energy planning between 2000 and 2015

2.1 Spatial and mobility planning crossovers

The milestone of the spatial and mobility planning literature in the last 15 years is the sustainable mobility paradigm's article (Banister, 2008). This paper defines a new approach in which transport and land use are integrated and co-jointed to reach sustainability goals. Main conclusion is that space and mobility should be linked and embedded in fundamental ways (Geerlings and Stead, 2003). This new approach inspired a consistent body of empirical research. In particular, several studies, continuing the previous and rich literature on this issue, question on the relation between mobility behavior and the density of development, proximity and quality of development, and local neighborhood and design factors. As a result, the debate whether a particular shape, a density threshold or a specific activities distribution can have an impact on the mobility behaviour and on cities sustainability is still undergoing (Echenique et al., 2012). Many studies have been produced focusing on the impacts of the urban form on mobility behaviour and the relative environmental and social impacts (Boarnet and Crane, 2001). In particular three specific urban structures have been assessed and studied with different approach and methodologies: the compact, the polycentric and the sprawl urban forms (Boelens, 2011; Coppola et al., 2014; Neuman, 2005). In more recent literature, a specific focus on Transit Oriented Development (TOD) raised, based on corridor developments along transit lines and on concentration of higher densities in stations areas (Cervero et al., 2002). In the most recent literature some new studies focus on the concept of "mobility environments" based on the spatial footprint of mobility and the possibility to define in space the specific mobility modes and behaviour (Bertolini and Dijst, 2003).
Another relatively recent concept in the transport and spatial planning cluster is the accessibility planning literature: researchers from various disciplines highlighted the benefits of adopting an accessibility-based approach in urban transport planning (Straatemeier, 2008). The focus on accessibility rather than mobility (Bertolini et al., 2005) results in a shift toward a more active involvement of spatial issues in the discussion (Curtis and Scheurer, 2010; Papa et al., 2016). The objectives of resource efficiency maximisation related to the notion of sustainability in transport planning are very much in line with the idea of improving accessibility with lower carbon-resource consumption.

2.1 Spatial and energy planning crossovers

The links between spatial planning and consumption of fossil fuels have been of interest since at least the 1940s, but in the last 15 years it evolved significantly. Indeed, in the last 15 years renewed and more situational research was executed with regard to this space and energy interrelation.
Spatial planning decisions have major impacts on the energy demand of the built environment as well as mobility connected with the spatial structures. One of the most cited study on the interrelation between energy and urban form is the Newman and Kenworthy (1996) publication on the relation between energy consumption and city form. The Mindali et al. (2004) study replies and criticises the original study that was then adapted and improved in the 2014 according to which density has a less role in energy use, as stated in the first analysis. On this subject, also other contributor has enriched the discussion in the last years and with application in different spatial contexts (Boussauw and Witlox, 2009; Marique and Reiter, 2012). The area of study is quite new, perhaps explaining why geographical studies into energy use are still largely descriptive. The studies are primarily concerned with describing the variability of energy costs at geographic and individual levels.
The received attention from researchers also has a specific regard to the building scale. Studies explored the effects of urban structures on building energy consumption. It highlights

that decisions made at the neighbourhood and city levels regarding built volume and surface, orientation of façades and obstructions have important consequences for the performance of individual buildings in heating, ventilation and cooling. In more recent years, the scale of analysis changed from the building to urban and regional, as scientific findings show that the achievement of a low carbon society depends not only on the energy performance and sustainability of the building stock, but also on the energy performance and sustainability of the urban organisation and infrastructure networks (Kenworthy, 2003). Several initiatives of urban planning point out, that energy-efficient settlement structures also lead to a high quality of life and have several features in common like decentralised concentration, multi-functionality, nearness within walking and/or biking distances as well as certain densities. Besides spatial organisation, spatial planning decisions also influence energy demand by choosing sites with a certain topography and exposition as well as by framing the built structures in building schemes.
Another group of studies is more focusing on a new emerging theme related to on-site energy production from renewable sources by means of thermal and photovoltaic panels, and the access to district energy supply and distribution technologies and the impacts of this transition towards spatial systems (Timmerman et al., 2014; Vansteenbrugge and Van Eetvelde, 2014). Sustainable energy systems, their generation as well as their utilisation are intrinsically linked to spatial planning. The reason for this prominence of space is that all renewable resources, solar radiation, wind and hydro power as well as bio-resources are area-dependent resource. Indeed, the theme attracted much attention because of the development of different forms of renewable energy, which is much more dependent on space than the use of fossil fuels (Sijmons et al., 2014). Another aspect of renewable resources is of importance when analysing the link between spatial planning and resource provision: renewable resources are de-centralised resources. This is of course a logical result of their dependency on space for their generation. This energy transition could influence spatial systems largely and challenges the urban as well as the rural environment to include the energy dimension in the spatial planning processes (Noorman and Roo, 2012).
Finally, another specific field of research seems to focus on the role of urban planning at different geographical scales in achieving energy policy goals (Zanon and Verones, 2013). They try to clarify the question if and how climate change and energy saving issues are to be included in urban policies and in planning practices. A large literature has been produced on the single country cases and study cases policies across the world in facilitating both household and commercial energy efficiency improvements and distributed energy generation, with the aim of providing affordable, secure and low-carbon energy service provision.

2.3 Mobility and energy planning crossovers

In mobility studies, energy use and its environmentally impacts are increasingly becoming a focus for transport researchers (Chapman, 2007; Schwanen et al., 2011). Nevertheless, the topic has largely been confined to the following fields: climate impacts of transport, usually quantified through estimates of the quantity of CO2 directly emitted by vehicles, or energy costs of transport modes, quantifying which modes of transport use most. Much of the investigation has focused on the technical characteristics of energy-using technology such as vehicles, and industrial processes: the relation between energy and mobility has been studied mainly with a techno-economic approach, focusing on the supply-side of vehicle technology efficiency gains and fuel switching. A specific focus, from 2005 onwards, has been dedicated on electric mobility (EM). Typically, the diffusion of advanced vehicle technologies is perceived as the central means to decarbonise transport. To this group of studies belong researches oriented at the study and the test of advanced vehicle technologies, proposing a variety of technological solutions, including greatly improved vehicular fuel efficiency, alternative fuels and propulsion systems, and carbon capture and storage (citation needed). Almost all studies suggest that technology’s long-term contribution to decarbonisation is likely to depend on macro-economic conditions – fuel prices in

particular – and policy decisions regarding carbon taxation and cap-and-trade schemes and land use policies.
The transport-energy nexus has also received attention from disciplines not traditionally associated with either issue, such as computer science, physics and psychology and transition studies. This group of studies also questions on how to implement transition management for a low carbon transport system; including new approaches for understanding innovation adoption processes and alternative business models through the modelling of the car market trends.
Another aspect which is studied in the mobility and energy literature is the “demand side” to reduce energy consumption and mobility, and regards car owning and car-sharing in the context of sustainable mobility (Ornetzeder and Rohracher, 2006). In these studies a new type of actor has emerges in the field of transport: mobility providers or operators, according to the MaaS, Mobility as a Service approach. Their business is to provide mobility services rather than a vehicle or a ride. Examples of new mobility providers are car-sharing organisations (CSO) offering car services in combination with public transport use. Some public transport companies are developing into mobility companies, by adding mobility services to their portfolio. This is a small but significant development for the future of sustainable, low energy demanding mobility.

2.4 Spatial, mobility and energy planning crossovers

Within the literature in the last 15 years on the crossovers between the three domains space, mobility and energy some clusters can be identified.
The first one includes researches that analyse relations between the mutual influences between energy provision, location and distribution of activities in space and mobility, analysing the reciprocal impacts of urban form on mobility energy consumption. These researchers investigate the link between spatial structure and energy consumption for travelling (Dujardin et al., 2014; Marique and Reiter, 2012) according to the principle that transport energy demand is a function of mode, technology and fuel choice, total distance travelled, driving style and vehicle occupancy.
A more innovative field of emerging studies is related to the new vision of the comprehensive space, mobility and energy approaches, based not anymore on the principle that societal energy consumption and related emissions are influenced by optimal efficiency but also by lifestyles and socio-cultural factors (Schwanen, 2013). They propose a variety of approaches and within different disciplines, addressing more directly some of the links between energy, societal change and their associated socio-political implications (Anable et al., 2012; Calvert, 2015; Figueroa et al., 2014; Guy and Shove, 2000; Marvin et al., 1999; Mattes et al., 2014; Rutherford and Coutard, 2014; Schwanen, 2015; Shove et al., 1998). A literature has emerged that foregrounds how changes to the attitudes, lifestyles, norms and values of the people contribute to behaviour change and decarbonisation. These behaviour changes encompass a whole variety of different types of choice related to travel demand and living styles. These aspects of research have contributed to recognition of, in particular the mutual influence between energy provision, space and mobility; and the weight of urban regions, activities and populations in the energy metabolism of contemporary societies. Furthermore another key aspect acknowledged in these studies is the importance of space (both in terms of transformation of the built environment and in terms of urban/territorial structures) in (transitions of) the supply and use of energy within urban regions.
Next to that, another field of studies are focussing of the policy implication of integrating energy, spatial and mobility measures for reducing energy use from both building and transport sectors. In many cases a top down approach still prevail, but some studies and research project are seeking to understand the rising capacity of urban actors to govern or influence energy-related change; and the importance of spatial communities as sites of energy-related innovations. Related to that, within the “smart city” literature, some studies focus on how information and communication technologies can have an impact of the energy saving and increasing efficiency.

3. A cross-sectorial and actor-relational approach for spatial, mobility and energy planning:

Space and mobility and energy interaction, and their underlying causes, have been explored with different approaches, at a range of different scales, but the proposed review suggests a gap in the literature, and highlights the need for space, mobility and energy innovative studies. The analysis conducted shows indeed some blind spots on the research on interaction space, mobility and energy.

In reflecting on the existing work and ongoing scientific debates, we see some overlapping areas of reflection, points of discussion and potential pathways for further research on emerging urban energy transitions, based on a more relational approach of the energy spatial mobility interactions. It is widely recognised that energy's decarbonisation is a massive challenge that can only be achieved by combining spatial and energy policies, means and measures targeting multiple elements within transport and land use systems – means of transport, their users, fuels, prices, regulations, infrastructures, the separation of origins and destinations – simultaneously (Banister, 2011). The space, mobility and energy crossovers can be seen as an emergent complex socio-spatial-technical system developing out of interacting dynamics between external societal landscape drivers, innovation within the current centralised energy regime and emerging, decentralised energy niches that involve technological, social innovation and/or institutional innovation. It is becoming more and more clear that those integrated researches needs to include behavioural aspects, based on shared economy principles. A new research agenda should indeed link this to transitions by showing that, alongside technological change, economic instruments, and behavioural changes, is one of the main strategies for achieving a transition towards climate change mitigation.

As a result, the integrated field of space-mobility-energy is not only highly complex – in the very essence of the word - but also very situational and specific. In this respect it is even remarkable that the majority of the contributions mentioned in the previous paragraphs is highly generic focused, privileging one solution for all, or privileging either a national or a supranational focus. In other words, a reduction in energy service demand from transport and living will be achieved through a myriad of individual and societal level shifts in preference for the amount of time travelling, the choice of destinations and where to live, attitudes towards health and the environment and the local community, different models of car ownership, driving behaviour as well as more 'standard' decisions about mode and car choice. That kind of literature on socio-technical transitions, and socio-psychological models of behaviour change, travel and living behaviour, is strongly influenced by concerns relating to health, quality of life, energy use and environmental implications.

With this in mind, a future research agenda should be based on innovative approaches, which address the multiplicity and fuzziness of our perceptions and actions in time and space concerning discursive, collaborative, informal and post-policy planning, as well as relational geography, multi-planar, non-linear and actor-relational approaches (Boelens, 2010; Boelens and de Roo, 2014). In other word, the new approach should be post structural, co-evolutionary, actor relational, situational and departing from specific transitions and ambitions, including hardware, software and orgware solutions reciprocally.

The perspective of local communities, actor-networks and/or upcoming integrated niches should be at the central focus: the urban scale is sometimes viewed as a bounded spatial or institutional form within which change happens, whereas, we argue, acknowledging the relational nature of the urban is central to studying and understanding contemporary urban change. A majority of the contributions still try to model the possible interrelations between energy transition, sustainable mobility and spatial planning and therewith fail to appreciate the very complexity and fuzziness of this interrelation itself. In other terms, the real interrelation within the cited domains could be achieved without thinking anymore in terms of "scientific domains" and boundaries, but in terms of energy, mobility and spatial actors, accordingly to a post-structural approach. On these bases, new studies should conceive processes towards a more sustainable space, mobility and energy transition in quite different ways.

Energy should be referred at the same time to many different things: a quantity consumed in mobility and residential decisions, a set of flow inputs and outputs of particular places, an infrastructure system through which electricity and heat are produced, transported, distributed, commercialized and consumed, or a policy instrument for the delivery of climate change mitigation strategies, etc. Space and mobility systems – instead of more or less territorially constituted and bounded – should be seen as actor-relational, covering various scales from the smallest parts of the built environment to global urban relations, including a narrow or wide set of actors beyond official policy-makers and elected politicians, etc. (Boelens, 2009, 2010).

Transition is less sectorially/spatially/socially focused, but more or less open and diverse, more or less political, etc. in which social processes start for a unclear beginning, with a fuzzy in-between, towards an unpredictable end; as a kind of undefined becoming (Boelens and De Roo 2014).

According to this, some examples of further researches should go towards for example: co-evolutionary transition of space, mobility and energy systems and the role of technology and planners; the impact of apps for less energy consumption and travel and spatial behavior; the reciprocal contributions of new mobility systems versus renewable energy systems in a mobile smart grid and its impact on space; impact of shared mobility systems for energy consumption and the spatial layout versus spatial behavior of citizens.

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