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This special issue collects a selection of peer-review papers presented at the 8th International Conference INPUT 2014 titled "Smart City: planning for energy, transportation and sustainability of urban systems", held on 4-6 June in Naples, Italy. The issue includes recent developments on the theme of relationship between innovation and city management and planning.

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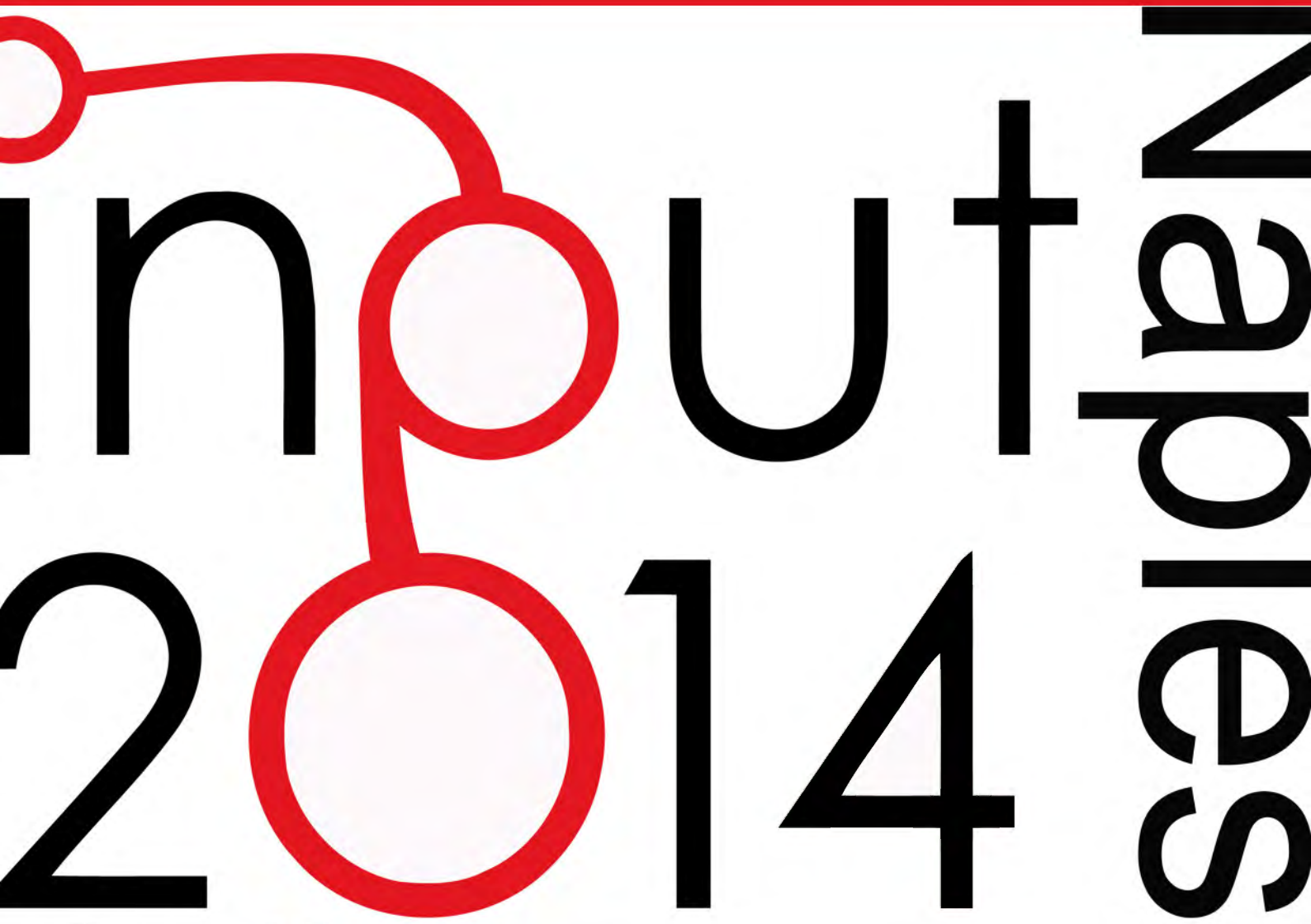

Smart City

planning for energy, transportation and sustainability of the urban system

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SMART CITY

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TeMA Journal of Land Use, Mobility and Environment

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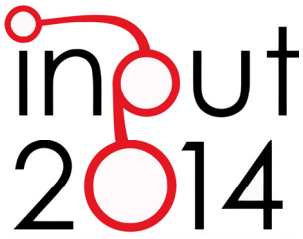
TeMA Journal of Land Use, Mobility and Environment

This special issue of TeMA collects the papers presented at the 8th International Conference INPUT 2014 which will take place in Naples from 4th to 6th June. The Conference focuses on one of the central topics within the urban studies debate and combines, in a new perspective, researches concerning the relationship between innovation and management of city changing.



TeMA Journal of Land Use, Mobility and Environment

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EIGHTH INTERNATIONAL CONFERENCE INPUT 2014

SMART CITY. PLANNING FOR ENERGY, TRANSPORTATION AND SUSTAINABILITY OF THE URBAN SYSTEM

This special issue of TeMA collects the papers presented at the Eighth International Conference INPUT, 2014, titled "Smart City. Planning for energy, transportation and sustainability of the urban system" that takes place in Naples from 4 to 6 of June 2014.

INPUT (Innovation in Urban Planning and Territorial) consists of an informal group/network of academic researchers Italians and foreigners working in several areas related to urban and territorial planning. Starting from the first conference, held in Venice in 1999, INPUT has represented an opportunity to reflect on the use of Information and Communication Technologies (ICTs) as key planning support tools. The theme of the eighth conference focuses on one of the most topical debate of urban studies that combines , in a new perspective, researches concerning the relationship between innovation (technological, methodological, of process etc..) and the management of the changes of the city. The Smart City is also currently the most investigated subject by TeMA that with this number is intended to provide a broad overview of the research activities currently in place in Italy and a number of European countries. Naples, with its tradition of studies in this particular research field, represents the best place to review progress on what is being done and try to identify some structural elements of a planning approach.

Furthermore the conference has represented the ideal space of mind comparison and ideas exchanging about a number of topics like: planning support systems, models to geo-design, qualitative cognitive models and formal ontologies, smart mobility and urban transport, Visualization and spatial perception in urban planning innovative processes for urban regeneration, smart city and smart citizen, the Smart Energy Master project, urban entropy and evaluation in urban planning, etc..

The conference INPUT Naples 2014 were sent 84 papers, through a computerized procedure using the website www.input2014.it . The papers were subjected to a series of monitoring and control operations. The first fundamental phase saw the submission of the papers to reviewers. To enable a blind procedure the papers have been checked in advance, in order to eliminate any reference to the authors. The review was carried out on a form set up by the local scientific committee. The review forms received were sent to the authors who have adapted the papers, in a more or less extensive way, on the base of the received comments. At this point (third stage), the new version of the paper was subjected to control for to standardize the content to the layout required for the publication within TeMA. In parallel, the Local Scientific Committee, along with the Editorial Board of the magazine, has provided to the technical operation on the site TeMA (insertion of data for the indexing and insertion of pdf version of the papers). In the light of the time's shortness and of the high number of contributions the Local Scientific Committee decided to publish the papers by applying some simplifies compared with the normal procedures used by TeMA. Specifically:

- Each paper was equipped with cover, TeMA Editorial Advisory Board, INPUT Scientific Committee, introductory page of INPUT 2014 and summary;
- Summary and sorting of the papers are in alphabetical order, based on the surname of the first author;
- Each paper is indexed with own DOI codex which can be found in the electronic version on TeMA website (www.tema.unina.it). The codex is not present on the pdf version of the papers.

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SPECIAL ISSUE

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Smart City - Planning for Energy, Transportation and Sustainability of the Urban System

Naples, 4-6 June 2014

THE FACTORS INFLUENCING TRANSPORT ENERGY CONSUMPTION IN URBAN AREAS

A REVIEW

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ABSTRACT

Transport energy consumption accounts for about one third of total energy consumption in EU. Despite significant advances in transport technology and fuel formulation, transport energy consumption has increased in most EU countries over the last three decades. This increase in consumption occurred as a result of factors such as higher car ownership, a growth in automobile use and an increase in vehicle distances traveled. As travel and land-use are a function of one another, it is often hypothesized that changing urban structure can result in changes in energy consumption. Understanding how different land use characteristics may influence travel behaviour and the corresponding energy consumption is crucial for planners and policy makers in order to develop strategic actions to shrink the environmental footprint of the urban transportation sector. The aim of this article is to review the current literature on the connections between land use, travel behavior and energy consumption. In particular, this paper seeks to identify the determinants of transport energy consumption in urban areas by reviewing evidence from empirical studies. To this aim, nine characteristics of land use are presented and their effects on both travel behaviour and energy use are discussed Our review shown that, in contrast to the focus on the effect of the built environment on travel, only few researchers have empirically investigated the linkage between the built environment and transportation energy use. The research described in this paper has been developed within the PON 04a2_E Smart Energy Master project. It represents part of a much broader research project aimed at the development of an integrated model of urban energy efficiency.

KEYWORDS

Transport energy consumption; Land use; Travel behavior

1 BACKGROUND AND GOALS

The energy challenge is one of the biggest issues facing Europe today. In 2012, EU-28 final energy consumption reached 1.104 Mtoe - approximately 15% of the world's energy consumption (Eurostat, 2012). A third of this amount was consumed by the transport sector (31.7%), the most energy-demanding sector, followed by households (26.6%), the industrial sector (25.3%) and services (20.4%). Over recent decades, there has been a decoupling of the energy consumption from the GDP although transport energy consumption has increased much more than in other sectors (European Commission 2012). Long-term forecast to 2030 suggest that energy consumption in Europe will increase in all major sectors and that the transport sector will experience the most rapid growth, increasing by 28% between 2000 and 2030 (European Commission, 2003).

Analyzing the transport energy consumption in the 27 European Countries at 2012 is possible to observe that there are large variations between countries.

Differences in income levels, fuel prices, urban structures and life-styles are some factors that explain these differences. These variations are even more noticeable at urban scale, especially comparing European cities with American and Asian cities. The overall energy use per passenger kilometer varies between 3,20 MJ/p.Km of US cities and 1,40 MJ/p.Km of high income Asian cities, while in the Western European cities energy use per passenger kilometer is 2.17 MJ/p.km (Kenworthy and Laube, 2001). Over the last two decades, significant advances in transport technology and fuel formulation has been reached. Due to national fiscal measures increasing taxes on inefficient cars and to high motor fuel prices, the specific consumption of new cars has decreased by 2.1 %/year on average for the EU between 1990 and 2010 (European Commission, 2012). However, neither the energy efficiency performances of new cars, nor national fiscal measures alone have shown to be able to reduce transport energy consumption (ibid). A first explanation of these trends may be found in the evolution of travel behaviour. The current trend is for more and longer trips mostly by private car and a reduction in the share of public transport in passenger traffic (European Commission, 2007). These changes in travel behaviour in turns are considered the results of important changes on urban features (Gakenheimer, 1999; Camagni et al., 2002; Li, 2010).

Given these premises, it is clear that transport energy consumption, travel behaviour and land use characteristics are strongly related. Understanding these connections is crucial for land-use planners and policy makers in order to implement strategies to shape sustainable mobility and to design and evaluate land use and transport policies aimed at reducing transport energy consumption in urban areas.

The purpose of this article is to review the current literature on the influence of land use characteristics on travel behavior, and further, on energy consumption.

In particular, this paper seeks to identify the determinants of transport energy consumption in urban areas by reviewing evidence from empirical studies. Despite some studies have identify the socio-economic profile of the population as the main explanation for travel behaviour and energy consumption (Stead et al., 2000; Mindali et al., 2004; Echenique et al., 2012), this discussion is limited to the influence of land use characteristics on travel behaviour and energy consumption. Indeed, although we recognize that land use factors are certainly not the only factors influencing both travel behaviour and energy consumption, we argue that they can provide the infrastructural and spatial conditions for a sustainable lifestyle, or, inversely, spatial constraints that can impede the adoption of such a lifestyle.

In addition, we to point out that land use factors can be worked out (within a certain extent) more directly by local planning instruments.

The work is organized as follow: the first part aims to briefly discuss the literature on the connection between land use, travel behavior and energy consumption. The second part focuses on nine land use characteristics that may affect travel behaviour and transport energy consumption. Finally, conclusion and major findings are presented.

1 CURRENT LITTERATURE

Stimulated by the increasing awareness that trends in urban mobility patterns are unsustainable, there is a large and still growing number of empirical studies on the relationships between urban form and travel patterns. A substantial body of literature on this theme has been produced since the 80's. Only between 2000 and 2009, more than 200 articles have been published on scientific journals (Ewing and Cervero, 2010). These studies usually examine one or more hypotheses about the expected effects of specific land use characteristics on trip frequency, trip lengths and travel mode or about the effects of changes in these characteristics either through the course of time or through planning policies. Aggregate studies on these themes were more favored in the early stage of the research, although some aggregate study has been produced in recent years. Yet, surprisingly, despite the substantial body of literature, still little consensus has been reached to date about how the built environment affects travel behavior. Some researchers, such as Boarnet and Sarmiento (1998) and Giuliano and Small (1993), showed that land use variables provided little explanatory power for observed travel. Others, including Krizek (2003) and Shen (2000), found that households change travel behavior when locating in differing built environments.

So far, relatively few researchers have empirically investigated the linkage between built environment and transportation energy use. It may be due to the lack of reliable energy data or because it has been often assumed that when longer distances are driven, more energy is consumed. Furthermore, many studies, such as those of Dodson and Sipe (2008), focus on home-to-work travel only to quantify the sustainability of travel patterns. Only in studies focusing on a small-enclosed area, different kinds of trips have been incorporated, as was done by Saunders et al. (2008). Even less conclusive is the extent to which the urban form impacts household energy consumption. Some authors believe that built environment factors such as higher density are expected to lead to a decrease in transportation energy consumption (Newman and Kenworthy, 1988; Karathodorou et al., 2010 among others). Some are more cautious and suggest that urban form factors are, at most, playing a partial role. Other factors, such as income and fuel prices are more important in influencing travel and energy consumption (Mindali et al., 2004; Susilo and Stead 2008).

Despite built environment, mobility patterns and energy consumption intertwine with each other, the existing studies has investigated how built environment affects people's travel behavior and travel outcomes (i.e. energy consumption and emission) in an isolated way. Only in recent years studies such as Liu and Shen (2011) or Brownstone and Golob (2009) has attempted to provide an unified pictures of the relationships between built environment, travel behaviour and transport energy consumption. These studies have specify and estimate structural equation models, a very powerful statistical modeling technique to handle a large number of endogenous and exogenous variables and to estimate the interactions among these variables by calculating direct effects, indirect effects, and total effects.

In the next section, nine characteristics of land use are presented and their effects on both travel behaviour and energy use are discussed. This work has necessitated a certain amount of compartmentalism into discrete land use categories. For this reason, some definitions may be overlapping or nested within each other. However, an explicit categorization of land use characteristics results very useful for the identification of the similarities and the differences between studies.

2.1 CITY SIZE

An important contribution in the study of the relationships between city size and energy efficiency is offered by Banister (1992). Analayzing a sample of English cities, he found that the higher is the population, the lower is the pre-capita transport energy consumption. However, Banister observes that London is not an energy-efficient city and that English cities, which contain an excess of 25,000 persons but smaller than London, were the most energy-efficient. The results of this research show that energy efficiency is expected to increases with increasing population, but when the city size is over its critical level, energy efficiency tends to decrease because of congestion. Many researchers including Banister said that the efficiency would be better as the size of city grew but it would be worse in cities bigger than the optimal size. However, there is no consensus about the optimum size of efficient city.

2.2 URBAN STRUCTURE

Bertaud (2003) defines the urban structure as “the physical outcome of the subtle interactions over centuries between land markets, and topography, infrastructure, regulations, and taxation”. In land use and transport research, concept such as “compact city” or “decentralized concentration” have been commonly used to describe different type of urban structure. However, evidence on the impacts of urban structure on transport energy consumption remain scarse. An important exception is the study of Shim et al. (2006). These authors have empirically investigate the relationships between urban form and energy consumption, using a sample of 61 Korean cities. They used the Gini coefficient for population concentration as a factor indicating the degree of population concentration. They studied and classified the cities as mononuclear or multinuclei with regard to the center distribution. By comparing the population Gini coefficient with yearly gasoline consumption per automobile and per person, Shim and his colleagues found that the energy efficiency is generally low in mononuclear cities, whereas the energy efficiency is high in multinuclei cities.

2.3 ROAD DENSITY

The road density, generally measured as the ratio of road length per urban area, is a useful parameter able to synthetically describe the provision of road infrastructures of a certain urban area. Su (2011) studied the effect of freeway road density, congestion and population density on household gasoline consumption in 50 U.S. urban areas. Using both semiparametric and parametric approaches, he found that households living in those urban areas with higher freeway densities, higher levels of congestion, or lower population densities consume more gasoline. Based on these findings, he concluded that “since gasoline consumption and road density are positively correlated, building more roads to reduce congestion clearly is not a good idea”. The hypothesis of a positive relationship between road density and travel demand in terms of vehicle miles traveled has been tested in various studies (Fulton et. al., 2000; Nolan and Cowart, 2000 among others) with results supporting the hypothesis. These studies support the concept of induced demand, in accordance with which the additions to roadway capacity result in increases in vehicle travel on the roadway above the level that occurred before the capacity addition.

2.4 POPULAION DENSITY

Population density, measured as the number of people, dwellings or households per square kilometers is probably the land use factor that has received more attention in the literature. One of the most cited studies on the relationships between density and energy consumption is that by Newman and Kenworthy (1989).

Using a sample of 32 cities in different countries and continents, they tested the influence of population density levels on the consumption of gasoline. These authors found that low-density metropolitan areas exhibit a higher pre-capita transport energy consumption and an almost total predominance of automobile use. In contrast, high-density metropolitan areas have a lower pre-capita transport energy consumption thanks to a greater share of public transport in passenger traffic. The conventional wisdom that there is a negative correlation between urban density and energy consumption in the transportation sector has been further supported by various studies. Karathodorou et al. (2010) used 84 cities from 42 different countries to investigate the impact of urban density on fuel demand. They concluded that density affects fuel consumption mostly through variations in the car stock and in the distances travelled rather than through fuel consumption per kilometer. Brownstone and Golob (2009) used the California subsample of the 2001 US National Household Travel Survey to test the impact of residential density on vehicle usage and energy consumption. Specifying a simultaneous equation model, they found that population density affects households' fuel consumption trough two main paths of influence: density directly influences vehicle usage, and both density and usage influence fuel consumption. Banister (1998) suggests that there are two important reasons why population density may reduce the ecological impact of mobility. First, higher density patterns result in a reduction of average distances between home and place of work; second, high densities may offer the proper conditions to foster successful public transport. These two hypothesis have been confirmed in numerous studies. For instance, Cervero and Murakami (2009) found a significant inverse effect of population density on vehicle miles travelled, while Giuliano and Narayan (2003) found that high level of density are positively related with a greater share in public transport.

2.5 LAND USE MIX

Land use mix is a measure of the integration of different activities (e.g. dwellings, workplaces, shops, schools and medical services) in a same area. Different measures of land use mix have been proposed in the literature like entropy indices (the variety of different uses in a neighborhood) or dissimilarity indices (the number of adjacent parcels with different uses). Both methods result in scores from 0 (least mixed use) to 1 (most mixed use). Another way to measure land use mix is using the jobs/housing balance ratio. Several studies have tested the hypothesis that mixed land use settlements allow for more walking and cycling trips and/or reduce travel distances. Wang et al. (2013) studied the relationships between land use mix and vehicle distance travel and emissions in conventional and smart growth communities. They found that vehicle miles traveled and CO2 emissions are lower for households that reside in mixed land use neighborhoods with good network connections. They suggest that as a long-term strategy, CO2 emissions reductions from smart growth developments can be substantial. Analysis by Sperry et al (2012) on a typical mixed-use site in suburban Dallas, shown that total trips increased, indicating induced travel, but many of these were walking trips, so total vehicle travel declined.

2.6 NEIGHBORHOOD DESIGHN

Neighborhood design includes street network characteristics within an area. Design can be measured using various indices, including intersection density, portion of four-way intersections, and portion of dead-end streets. Design is also measured as sidewalk coverage, numbers of pedestrian crossings or others physical variables that characterize pedestrian-oriented environments. Many studies tested the hypothesis that high intersection density and great street connectivity are positively related with a greater share of walking and cycling, as they shorten access distances to opportunities. Larco et al. (2010) studied 14 multifamily housing

developments in Eugene, Oregon. Using both descriptive statistics and regression models, they found that increasing connectivity can significantly increase use of alternative modes. In particular, residents of more-connected developments were more than twice as likely to walk or bike to local amenities than residents in less connected locations. Urban sites with small blocks and extensive sidewalk systems were found to have, on average, three times the pedestrian volumes of suburban sites with large blocks and short or incomplete sidewalk systems.

2.7 LOCATION

Location refers to the relative position of a certain urban area with respect to the city center or, more in general, with respect to those areas with high concentration of urban activities. Several studies have analyzed the relationships between geographical location and energy consumption. Using multivariate analyses, Naess, 2010 tested the influence of dwellings' location on travel and energy use in the Hangzhou Metropolitan Area, China. The location of dwelling was described using three variables: location of the dwelling relative to i) the city center of Hangzhou ii) the closest second-order center iii) the closest third-order center. His analysis shown that living close to the city center contributes to less overall travel, a higher proportion of trips by bicycle and on foot, and lower consumption of energy for transport. The location of the dwelling relative to the closest second-order and third-order center also has some influence on transport energy consumption, but not to the same extent as proximity to the city center. Naess and Sandeberg (1996) analyzed the commuting transport energy consumption of six important Swedish companies' employs. Their analysis indicate that the geographical location of jobs has a strong impact on commuting energy use. In particular, they found that employees of workplaces in peripheral, low-density parts of the urban area are far more frequent car drivers and use considerably more energy for journeys to work than employees of workplaces located in central high-density areas.

2.8 DESTINATION ACCESSIBILITY

Since the seminal pare by Hansen (1959), many definitions of accessibility and relative measures have been proposed in the literature (see Geurs and van Wee, 2004 for an extended review). However, in research on the influence of the built environment on travel behaviour, accessibility has been often measured using relatively simple indicators such as the number of jobs within a certain travel time. Levinson (1998) studied the effects of accessibility on the journey to work. Using data from a travel survey in the Metropolitan Area of Washington, he found that residences in job-rich areas and workplaces in housing-rich areas are associated with shorter commutes. Moniruzzaman and Páez (2012) investigated the implications of accessibility to transit and by transit for mode shares in the city of Hamilton, Canada. Modelling transit shares by means of a logistic regression, they found that accessibility by transit is a significant predictor of modal share. Owen and Levinson (2013) calculate accessibility for both transit and auto in Minneapolis urban area. They found that the modal accessibility disparity (i.e. the ratio between transit and car accessibility) is a valuable predictor of commute mode share.

2.9 DISTANCE TO TRANSIT

Distance to transit is a measure of the ease to access to public transport facilities. It can be measured as the straight-line distance or the network distance to a certain transport facility. As distance to transit represents the proximity of the demand (population and employees) to stops or stations on the network, many studies has tested the hypothesis of a direct relationship between distance to transit and transit likelihood. Crowly et

al. (2009) examined how variations in walking distance to transit are related to mode choice as well as to car ownership and use. Their analysis shown a strong association between walk access and transit use, not only during peak hours but also throughout the day, concluding that the promotion of focused development within a convenient walking distance of transit service can significantly affect transit ridership even in a relatively low-density area.

3 CONCLUSIONS

With the growth in automobile use and increase in daily distance travelled, the transportation sector's shares of energy consumption is significant and increasing. As travel and land-use are a function of one another, many research has tested the hypothesis that changing urban structure can result in changes in energy consumption. Understanding how different land use characteristics may influence travel behaviour and the corresponding energy consumption is crucial for planners and policy makers in order to develop strategic actions to shrink the environmental footprint of the urban transportation sector.

FACTORS	EXPECTED IMPACTS
City size	Energy efficiency is expected to increases with increasing population, but when the city size is over its critical level, energy efficiency tends to decrease because of congestion.
Urban Structure	Energy efficiency is generally low in mononuclear cities, whereas the energy efficiency is high in multinuclei cities. However, positives studies about this are lacking.
Road density	An increase of road density is expected to increase energy consumption. According to the concept of induced demand, additions to roadway capacity result in increases in vehicle travel on the roadway (and the network) above the level that occurred before the capacity addition
Population density	Density has a significant inverse effect on energy consumption through several channels: increase in density are associated with i) shorter distance travelled ii) a highest use of public transport and iii) a higher ownership of fuel efficient private vehicles.
Land use mix	Mixed land use settlements allow for more walking and cycling trips. Traditional neighborhoods have shorter trips than car-oriented suburbs.
Neighborhood design	Neighborhood characterized by high intersection density and great street connectivity exhibit a greater share of walking and cycling, as they shorten access distances to opportunities.
Location	Some research has found a negative correlation between the distance to the city center and the transport energy consumption: living close to the city center contributes to less overall travel, a higher proportion of trips by bicycle and on foot, and a lower consumption of energy for transport.
Destination accessibility	Residences in job-rich areas and workplaces in housing-rich areas are associated with shorter commutes. Urban areas characterized by high transit accessibility level are associated with a great share in public transport.
Distance to transit	Distance to transit is considered the most important factor influencing public transport use.

Tab. 1 Factors influencing transport energy consumption

In this article a review of the current literature on the connection among land use, travel behavior and transport energy consumption has been presented. In particular, this article has identify and discussed nine land use characteristics that may influence transport energy consumption in urban areas by analyzing evidence from empirical studies. This review has explicitly categorised the literature according to discrete aspects of built environment, which allows for a clearer identification of the similarities and differences between studies.

The review has shown that there is a large amount of literature from around the world on the relationships between urban form and travel characteristics. Yet, surprisingly, despite the substantial body of literature, evidence remains so far contradictory. Van Wee (2002) identified several reasons of the causes for different results from research, including the difference in the width of the sample analyzed, the geographical scale, and cultural differences among countries, which may result in other effects of the same land-use concepts. In contrast to the focus on the effects of the built environment on travel behaviour, only few researchers have empirically investigated the linkage between the built environment and transportation energy use. Much of the empirical literature on transport energy consumption presents estimates derived from city level data, which account for variations within the cities but ignores the variability of land use patterns between places of the same city. Even at a more disaggregated scale, research in this field have often considered only few aspects of the built environment. These issues therefore call for more empirical work and more sophisticated and comprehensive description of the built environment. It is not enough to describe urban areas using aggregate statistics at city levels, nor using general characteristics such as density, size and distance to nearest center. In order to have a deeper understanding of land use-energy connection, we need to move towards a more integrated and 'seamless' description of the built environment at both the neighborhood and the metropolitan scale.

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