SPECIAL Expert Paper 3

SPATIAL PLANNING and ENERGY for COMMUNITIES IN ALL LANDSCAPES

Co-funded by the Intelligent Energy Europe Programme of the European Union

Making the connection – energy, transport and urban planning

An integrated approach to improving the energy efficiency of transport systems

Centro Nazionale Studi Urbanistici

By Giuseppe Inturri and Matteo Ignaccolo

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About SPECIAL

Spatial planning has a key part to play in creating urban environments that support less energy-intense lifestyles and communities, and spatial and urban planners have a pivotal role in developing energy strategies and action plans. The SPECIAL (Spatial Planning and Energy for Communities In All Landscapes) project has been set up to help bridge the gap between climate change/energy action planning and spatial and urban planning.

SPECIAL is funded by Intelligent Energy Europe and is an exciting partnership between eight Town Planning Associations (TPAs) and planning authorities from across Europe. It is a three-year programme with a focus on spatial planning for the deployment of local energy efficiency and renewable energy solutions. The Town and Country Planning Association (TCPA) is the lead partner, with partner TPAs and planning authorities in Austria, Germany, Greece, Hungary, Ireland, Italy, and Sweden.

The project has been set up to help the TPAs and planning authorities of the partner countries meet the EU's challenging energy and climate change targets for 2020. It has several objectives relating to exchanging best practice and experience; promoting integrated renewable energy strategies; and building the capacity of the partner planning associations and authorities in the planning and delivery of renewable energy solutions. Most importantly, the partners must then share that learning through their professional networks and maximise the dissemination of their training to others, in a multiplier effect.

The SPECIAL partnership:

- Provincial Government of Styria, Department of Spatial Planning Law, Austria
- German Institute of Urban Affairs, Germany
- Organisation for the Master Plan and Environmental Protection of Thessaloniki, Greece
- Hungarian Urban Knowledge Centre, Hungary
- Irish Planning Institute, Ireland
- National Centre for Town Planning Studies, Italy
- Swedish Society for Town and Country Planning, Sweden
- Town and Country Planning Association, UK

The SPECIAL project runs from March 2013 to March 2016, with a final conference held in London to disseminate the project outcomes, including a pan-European Guide on Spatial Planning and Sustainable Energy.

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Cover illustration: The TransMilenio BRT of Bogotà, courtesy of Scania (http://newsroom.scania.com/en-group/2013/07/02/choose-the-bus-for-the-environment/)

1 Introduction

This SPECIAL project Expert Paper considers the key role that urban transport plays in meeting the Europe Union's target of at least a 27% improvement in energy efficiency and a 40% reduction in greenhouse gas (GHG) emissions by 2030.[1] It highlights the opportunities for improving energy efficiency through a combination of integrated land use and transport planning and the exploitation of new vehicle technologies.

An integrated land use and transport policy – such as a Sustainable Urban Mobility Plan – is one of the most long-term, strategic and effective ways of both reducing carbon dioxide emissions and improving the security of energy supply. The number of measures aimed at reducing the transport energy dependence of cities across Europe is growing. Most rely on three basic strategies:

- reducing the need for, and length of, trips;
- shifting to low-energy transport options such as public transport and non-motorised modes; and
- using improved vehicle efficiency technology and cleaner fuels.

This Expert Paper highlights good practice in improving the energy sustainability of urban transport systems. It is aimed primarily at local authority planners, councillors and private sector practitioners, but is also intended to be useful for architects, energy practitioners, renewable energy providers, transport planners and anyone else seeking to tackle climate change and reap the positive economic benefits that renewable energy approaches and low-carbon living can bring.

1 '2030 Climate and Energy Framework'. Webpage. European Commission. **http://ec.europa.eu/clima/policies/strategies/2030/index_en.htm**

2 Urban transport, energy and climate change

2.1 Background

In 2013 the transport sector used nearly one-third of all energy (see Fig. 1) and 70% of all oil consumed in the EU. While the emission rates of most GHG sources are starting to ease off, those related to transport have increased steadily: up by 29% on 1990 levels in the EU27 countries in 2007. The data demonstrates a reduction in emissions from transport as a result of the impact of the economic crisis in 2008, which confirms the strong relationship between economic growth and transport activity. In 2012, road transport contributed 72% of all transport-related GHG emissions (see Fig. 2).

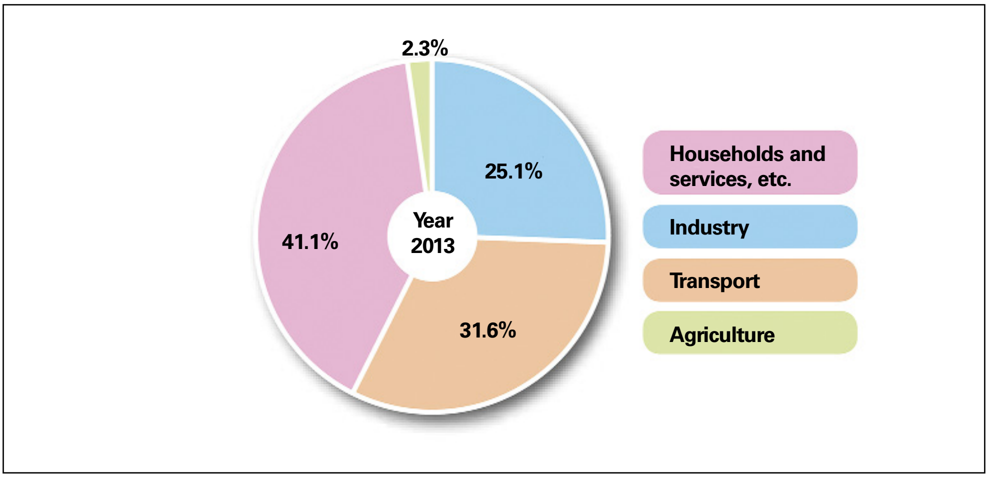

Fig. 1 Energy consumption by sector – EU28, 2013
Source: EU Transport in Figures. European Commission, 2015. http://ec.europa.eu/transport/facts-fundings/statistics/doc/2015/pocketbook2015.pdf

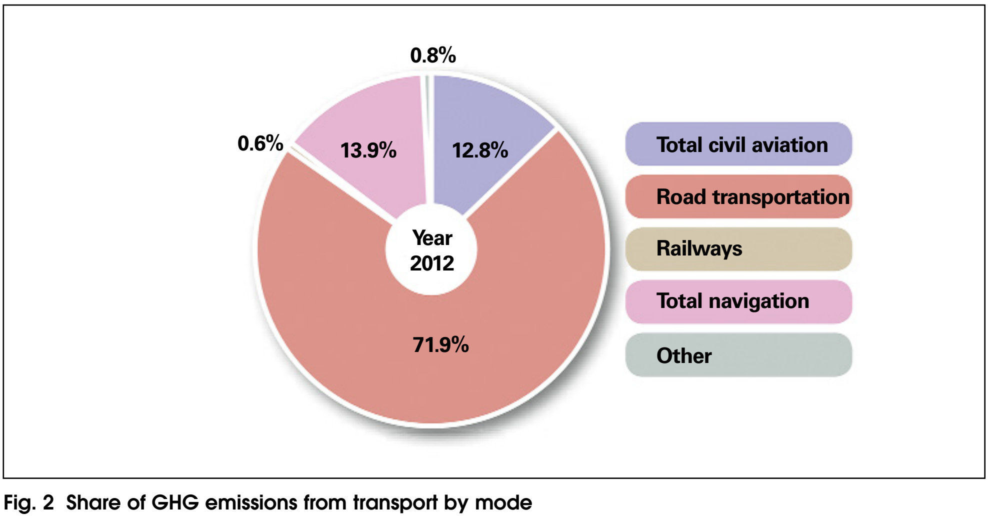

Fig. 2 Share of GHG emissions from transport by mode
Source: EU Transport in Figures. European Commission, 2015. http://ec.europa.eu/transport/facts-fundings/statistics/doc/2015/pocketbook2015.pdf

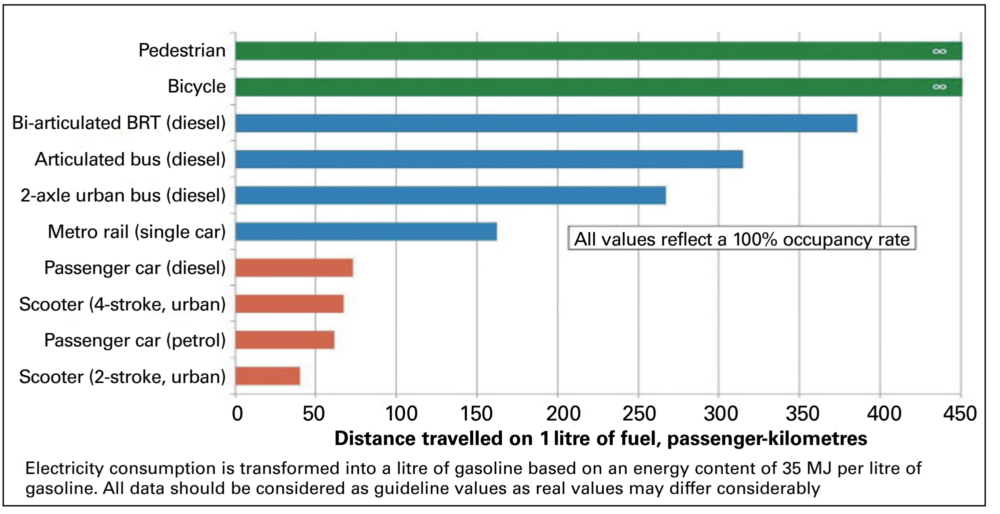

Fig. 3 The energy efficiency of different modes of urban transport
Source: S. Bohler-Baedeker and H. Huging: *Urban Transport and Energy Efficiency. Sustainable Transport: A Sourcebook for Policy Makers in Developing Cities.* Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ), Germany, 2012. Module 5h.
http://www.sutp.org/files/contents/documents/resources/A_Sourcebook/SB5_Environment%20and%20Health/GIZ_SUTP_SB5h_Urban-Transport-and-Energy-Efficiency_EN.pdf

2.2 The energy efficiency of different transport modes

The energy efficiency of a conventionally propelled car is surprisingly low (see Fig. 3). Consider the total fuel energy entering an internal combustion engine (ICE) of a medium passenger car: only an average of 13% of the energy consumed actually drives the wheels. The remaining 87% is dissipated in the engine, transmission, drivetrain and vehicle accessories, and when the engine idles.[2] Occupants of a car typically account for only 6% of the total vehicle weight, so only about 1% of the total fuel energy is actually used to move the 'payload'. This is one reason why sustainable mobility policies generally aim to reduce car use and promote the use of public transport, walking and cycling.

If cities are to achieve a 60% reduction in GHG emissions as required by the European Commission, they need to adopt a radical change in their approach towards sustainable transport systems.[3] There are several initiatives that can help them achieve this. For example, the local authorities supporting the Covenant of Mayors initiative have agreed to reduce transport-related carbon dioxide emissions by 20% by 2020 through the adoption of a Sustainable Energy Action Plan (SEAP), in which transport plays a key role. The Action Plan on Urban Mobility supports local authorities in developing Sustainable Urban Mobility Plans (SUMPs), which are also promoted by the ELTISPlus initiative.[4]

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2 A. Schafer, J.B. Heywood, H.D. Jacoby and I.A. Waitz: *Transportation in a Climate-Constrained World.* MIT Press, 2009

3 *Roadmap to a Single European Transport Area: Towards a Competitive and Resource Efficient Transport System.* White Paper. COM(2011)final. European Commission, 2011.
http://ec.europa.eu/transport/themes/strategies/doc/2011_white_paper/white_paper_com(2011)_144_en.pdf

4 *Action Plan on Urban Mobility.* Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. European Commission, 2009.
http://ec.europa.eu/transport/themes/urban/urban_mobility/action_plan_en.htm

3 Transport planning strategies and actions to bring about low-carbon communities

3.1 Strategies

Urban transport energy efficiency policies are directly dependent on three main factors:

- the amount of transport activity, i.e. how far people travel;
- the number of people sharing the transport vehicle, i.e. the capacity of the vehicle multiplied by the load factor; and
- the energy intensity involved. i.e. the amount of energy required to move the vehicle per unit of distance.

Passenger transport related energy E_t is calculated as (units in square brackets):

$$E_t\,[\text{kWh}] = \textit{Persons} \times \textit{Distance}\,[\text{km}] \times \frac{\textit{Vehicle consumption}\,[\text{kWh/km}]}{\textit{Vehicle capacity} \times \textit{Load factor}}$$

Increasing the energy efficiency of transport requires a reduction in each of these factors (persons travelling, distance travelled, and energy intensity). The values of some efficiency indicators in various regions are shown in Table 1. The lowest energy

Table 1
Examples of values for different efficiency indicators

Indicator	US cities	Western European cities	High-income Asian cities	Latin American cities	African cities
Territorial efficiency					
Passenger transport energy use, kWh/person	16,676	4,354	2,654	2,173	1,718
Private individual mobility, passenger-km/capita	18,200	6,321	3,971	2,966	2,711
Urban density, persons/km^2	1,490	5,490	15,030	7,470	5,990
Transport efficiency					
Non-motorised modes, %	8.1	31.3	28.5	30.7	41.4
Public transport, %	3.4	19.0	29.9	33.9	26.3
Motorised private modes, %	88.5	49.7	41.6	35.4	32.3
Energy use per public transport passenger-kilometre, kWh/passenger-km	0.59	0.23	0.13	0.21	0.14
Vehicle efficiency					
Energy use per private transport vehicle-kilometre, kWh/passenger-km	1.28	0.92	0.92	1.03	1.03
Energy use per public transport vehicle-kilometre, kWh/passenger-km	7.31	4.08	4.00	4.69	2.64

Source: Adapted from J.R. Kenworthy: *Transport Energy Use and Greenhouse Gases in Urban Passenger Transport Systems: A Study of 84 Global Cities*. International Sustainability Conference, Fremantle, Western Australia, 17-19 Sept. 2003 efficiency values are found in US cities, which have the highest transport energy consumption rates (16,676 kWh) per person, mostly related to car use (88.5%). This is because low-density urban areas give rise to long-distance journeys by private transport, while the low price of fuel favours high energy intensity vehicles (1.28 kWh/km).

These efficiency indicators set the framework for the three basic strategies for reducing transport energy use and GHG emissions:[5]

- *avoid*, by reducing the need to travel and trip length, which leads to a reduction in overall transport use;
- *shift*, by encouraging a modal shift toward sustainable transport modes, which reduces the number of units of transport and the energy required per unit of transport; and
- *improve*, by increasing the efficiency of transport systems, which reduces the impact per unit of energy used (for example, carbon dioxide emissions).

These strategies have to be integrated into a holistic approach across the fields of land use, transport and technology development (see Fig. 4).

3.2 Actions

The above strategies are implemented through a set of actions, generally included in a transport plan. Actions can be categorised according to the following five instruments:[6]

- ***planning instruments*** – comprising all measures that concentrate on the spatial planning of transport infrastructure, public transport and non-motorised modes; 'smart growth', 'new urbanism', transit-oriented development, green infrastructure and planning for accessibility are all planning approaches that are widely accepted as being effective;

5 H. Dalkmann and C. Brannigan: *Transport and Climate Change – Sustainable Transport: A Sourcebook for Policy Makers in Developing Cities*. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Germany, 2007. Module 5e. http://siteresources.worldbank.org/EXTAFRSUBSAHTRA/Resources/gtz-transport-and-climate-change-2007.pdf

6 *Ibid*.

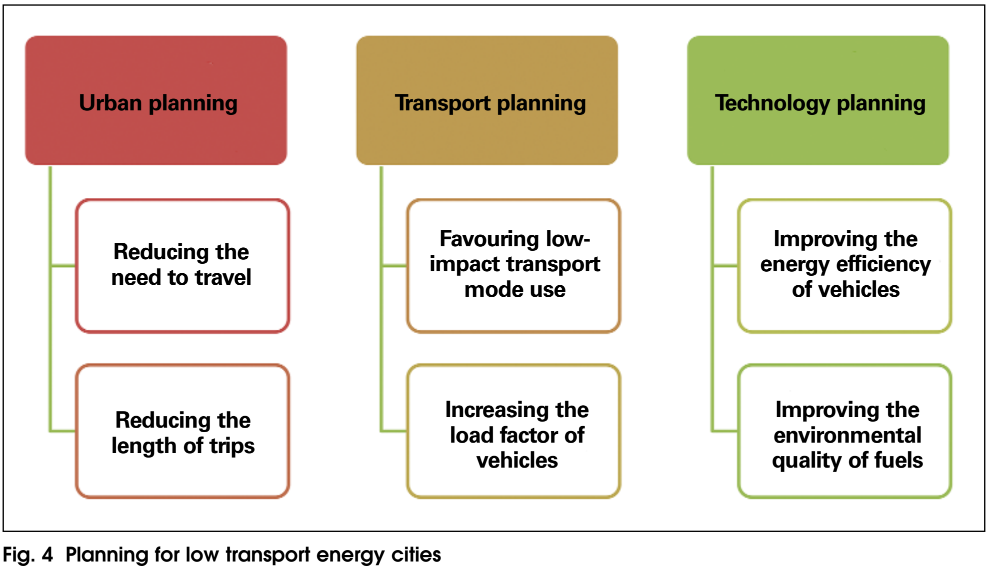

Fig. 4 Planning for low transport energy cities

- ***regulatory instruments*** – including all norms, standards and measures that limit the impacts of traffic, such as emissions and speed limits, traffic restrictions, maximum parking regulations, and so on;
- ***economic instruments*** – internalising the external costs of transport to shift the economic burden from ownership (fixed cost) to use (variable cost); charges and taxes are administered to encourage more energy-efficient vehicles, reduce demand for transport and encourage modal shift (road pricing, parking charges, carbon taxes and pay-as-you-drive insurance schemes are well known examples of economic tools for transport demand management);
- ***information*** – including public awareness campaigns and mobility management schemes that can be developed to stimulate the use of alternative means of travel; and
- ***technology*** – focusing on fuel improvement, new propulsion technology, and intelligent transport systems.

The remainder of this Section sets out examples of regulatory, economic and technological instruments. Section 4 explores planning instruments in more detail.

3.2.1 Speed restrictions

Fuel consumption for cars and trucks usually increases at higher speeds (generally above 50 kilometres per hour). One way of reducing vehicular GHG emissions is to consider implementing lower speed limits. Carbon dioxide emissions increase at low driving speeds as a consequence of congestion or within urban areas. At higher speeds emissions are increased as vehicles have to work harder against air resistance. Various strategies can be adopted to reduce traffic speeds, such as narrowing new and existing streets, smart signs that display the speed of vehicles as they drive by, driver education, synchronising traffic signals to be optimised for lower traffic speeds, and built-in vehicle systems that automatically alert drivers when they exceed speed limits or prevent speeding altogether.

An example of the successful implementation of speed restrictions is provided by the city of Graz, in Austria. After a year-long discussion in which several parts of the city demanded the introduction of 30 kilometres per hour zones, a unique experiment started in 1992: Graz became the first city in Europe to implement a speed limit of 30/50 kilometres per hour for the whole city area. A 30 kilometres per hour speed limit was put into effect on all side roads and in front of schools and hospitals, thus covering around 80% of the whole city. A speed limit of 50 kilometres per hour was imposed on all major roads, to increase road safety and reduce both pollution and noise. For major roads, a traffic safety monitoring group (made up of city experts, police and consultants) identified and provided solutions to overcome danger zones on major roads, through, for example, changes to traffic light timings, the reconstruction of roads and intersections and the introduction of additional traffic lights, together with further speed limits. At present, Graz has about 800 kilometres of 30 kilometres per hour zones. The number of people injured in traffic has fallen by 15%, and, particularly significantly, the severity of injuries has fallen. The 30/50 kilometres per hour speed limits are now firmly established and the majority of the population has abandoned any initial objections.

3.2.2 Road pricing

Road pricing, sometimes called congestion pricing or congestion charging, is a system that charges for road use. It aims to apportion scarce road space by market pricing rather than queuing. In congested areas each road trip forces other users to slow down and increases trip times. In the absence of a toll, a driver does not have to pay for the additional costs he or she imposes on others. When this cost is ignored, the market fails. The situation can be improved by corrective policy measures, a toll being the main example. The aims of road pricing are to control rising congestion levels, deter further growth in car use, and address the negative impacts of traffic and congestion on transport efficiency and the environment. It has significant potential to reduce GHG emissions: drivers respond to the 'price signal' and adjust their driving habits accordingly. Table 2 sets out the characteristics of the major city systems in operation.

3.2.3 Parking charges

Charging for the space used for parking is one of the most effective policies for increasing car sharing and inducing people to use alternative low-carbon modes. Surveys conducted in six European countries suggest that parking fees can act as a significant deterrent to car use, with an increase in the price resulting in a reduction in car use (see Fig. 5). Parking-related policies can take a wide range of forms and are often more readily accepted than road pricing. Public acceptance is much more likely if the revenue resulting from parking charges is used to supply facilities and services for sustainable mobility. For example, approximately 3,000 road parking spaces in Paris were converted to Vélib bicycle share stands between 2006 and 2008.

3.2.4 Electric mobility

A conventional car powered by a fossil fuelled internal combustion engine uses approximately 0.80 kWh of energy per kilometre. The energy goes into the brakes each time the car stops (losing its kinetic energy), air resistance (especially at high speeds) and rolling resistance, while almost 75% of the energy is lost as heat because the energy conversion chain is inefficient. The energy consumed by a conventional car can be reduced by adopting an aerodynamic shape or by reducing its weight through innovative materials and design. The progress in improving the energy efficiency of conventionally powered new cars has slowed following a general market trend

Table 2
Characteristics of some notable road-charging schemes

City, scheme and implementation date	Scheme type	Area, km^2	Operating hours	Price	Enforcement system
Singapore, Electronic road pricing, 1975	Cordon ring (inner)	7	Mon-Sat, 7.00-22.00	Gantry/time dependent €0-15	Radio-frequencies and cameras
London, Congestion charge, 2003	Cordon ring (inner)	40	Mon-Fri, 7.00-18.30	Flat rate, £8/day	CCTV cameras
Stockholm, Congestion tax, 2006 (made permanent 2007)	Cordon ring (inner and outer)	35	Mon-Fri, 6.30-18.30	€1-2 per crossing dependent on time of day	Laser and cameras
Milan, Ecopass, 2008 (temporary, extended to end of 2011; superseded by a new scheme in 2012)	Cordon ring (inner)	8	Mon-Fri, 7.30-19.30	€2-10/day	Digital cameras

Source: Transport, Energy and CO_2: Moving Toward Sustainability. International Energy Agency, 2009. https://www.iea.org/publications/freepublications/publication/transport2009.pdf

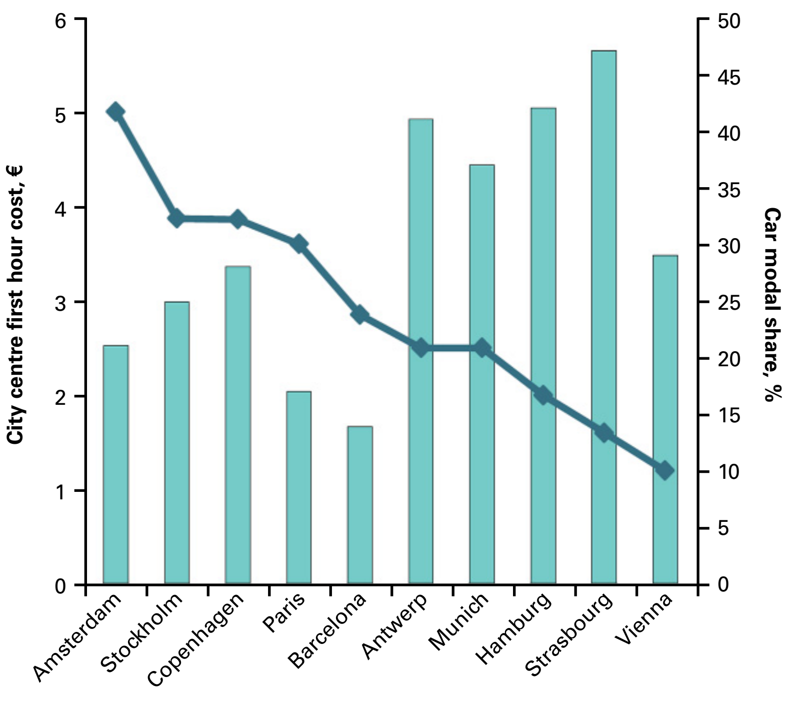

Fig. 5 The impact of parking charges on car modal share
Source: A Closer Look at Urban Transport – TERM 2013: Transport Indicators Tracking Progress towards Environmental Targets in Europe. Report 11/2013. European Environment Agency, 2013.
http://www.eea.europa.eu/publications/term-2013

towards larger, heavier and faster cars. In any case, 75% of the problem still remains – in the low fraction of energy that can be extracted from fossil fuels and transformed into mechanical power for propulsion.

Electric mobility is one of the most promising technological opportunities to increase the energy efficiency of transport systems and reduce the impacts per unit of energy used, such as carbon dioxide emissions. The internal combustion engine has been the prevalent propulsion motor in the last century, while electric motors have been mostly used for transit rail systems or trolleybuses powered through a collector system by electricity from off-vehicle sources. It has been estimated that electrifying the whole transportation sector could shrink energy consumption to one-fifth of current levels.[7] In addition, electrifying the transport sector would promote sustainable ways of generating electricity, such as wind and solar power.[8] There are also advantages for air quality and human health, such as in the reduction of particulate pollution and acid rain.[9]

7 D.J.C. Mackay: *Sustainable Energy – Without the Hot Air*. UIT Cambridge, 2009

8 W. Short and P. Denholm: *A Preliminary Assessment of Plug-in Hybrid Electric Vehicles on Wind Energy Markets*. Technical Report NREL/TP-620-39729. National Renewable Energy Laboratory, Golden, Colorado, 2006. **http://www.nrel.gov/docs/fy06osti/39729.pdf**

9 B.K. Sovacool: 'A transition to plug-in hybrid electric vehicles (PHEVs): why public health professionals must care'. *Journal of Epidemiology & Community Health*, 2010, Vol. 64 (3), 185-7

The wide take-up of electric cars for individual mobility depends mostly on their ability to store enough energy to travel acceptable distances before needing to be recharged. While the weight of the energy store, per useful kilowatt-hour stored, is about 25 times bigger than that of petrol, the weight of an electric engine can be about eight times smaller. Furthermore, the energy chain in an electric car is much more efficient: electric motors can achieve 90% efficiency.[10] An electric car consuming around 150 Wh/km and with a battery capacity of 25 kWh has a range of around 160 kilometres. Its battery capacity is the equivalent of the energy of three litres of petrol (based on 53 kilometres travelled per litre of petrol). Up to now, electric cars have high energy efficiency but low energy density and a low range.

The environmental concerns of the last decades and recent technological developments in the field of electric storage have brought higher energy density and longer life span batteries into the market. For an energy density of 40 Wh/kg (typical of lead acid batteries), it is hard to push the range beyond 200-300 kilometres. But for an energy density of 120 Wh/kg (typical of various lithium-based batteries), a range of 500 kilometres is easily achievable. The availability of on-board energy storage using light and powerful batteries for electric cars appears to have the potential to overcome the energy inefficiency and related drawbacks of conventional internal combustion engines.[11]

Two big classes of electric vehicles are now available on the market: battery electric vehicles (BEVs), also known as pure electric vehicles, and hybrid electric vehicles (HEVs). BEVs use batteries to store energy that is transformed into mechanical power by an electric motor. In HEVs propulsion is the result of mechanical power provided both by an electric motor and an internal combustion engine (ICE).

The batteries of conventional HEVs are recharged by means of the ICE, while the so-called plug-in hybrids (PHEV) can have their batteries recharged directly from the power grid, which reduces dependence on less eco-friendly gasoline stations. The electric motors of BEVs have an energy efficiency of 85% compared with 30-34% for an ICE. They do not emit noise and air pollution, while the amount of GHG emissions depends on the mix of the primary energy sources. HEVs combine the advantages of high-range ICEs and the electric drivetrain (high motor efficiency and zero idling losses). The ICE is mostly used when cruising at higher speeds or acts as a generator to produce electricity, exploiting its good efficiency at constant operating regimes. The electric motor typically propels the vehicle during most stop-and-go (urban) driving, uses its high torque at low speed and acts as a generator during braking. In total, HEV consumption is 30-40% less than an ICE counterpart.

Electric vehicles are not the panacea for the impacts of road traffic in urban areas: occupation of space is still the same, even if the car is electric, and the actual characteristics of the emissions of an electric vehicle depends on the fuel mixture used by each country to generate electricity. Reducing the need for motorised mobility and shifting to public and active transport are still the best strategies to move to low-carbon cities; however, technological improvements in the field of electric propulsion have strong potential to reduce Europe's oil dependence.

10 D.J.C. Mackay: *Sustainable Energy – Without the Hot Air*. UIT Cambridge, 2009

11 *Ibid*.

4 The urban planning, transport and energy connection

Remarkable efforts have been made during the last decade to reduce carbon dioxide emissions by developing cleaner fuels and improving vehicle performance and efficiency. On the other hand, driving rates continue to increase; growth rates for passenger and freight transport are much higher than for population. This is not only because people travel more (provided economic growth is occurring), but also because their journeys are longer. The private car is still used for more than 80% of total inland passenger motorised intra-EU journeys (see Fig. 6). There is evidence that more effective planning is needed to achieve sustainable mobility. This should focus on better knowledge and relevant measures that concentrate on spatial planning and transport systems to reduce transport energy dependence and GHG emissions.

4.1 Integrated approaches to land use and transport planning

4.1.1 Public transport networks

Integrating land use and transport planning is the strongest and most effective long-term strategy for achieving low-carbon cities and transport energy efficiency. In the recent past, major and visionary regional railway projects have transformed most European cities into great metropolitan areas. These include:

- the General Plan of Stockholm in 1952 and its heavy rail metro system (see Fig. 7);
- the Schéma Directeur of Paris in 1965, which led to very large *cités nouvelles* linked to the main city by the totally new Réseau Express Regional (RER) rail system; and
- Berlin's City Express Rail network – the Stadt-Schnellbahn (S-Bahn) – that serves small villages 30-40 km from the city.

Similar land use and transport approaches can be found in Vienna, Zurich and Copenhagen.

Other approaches include the renaissance of tram and light rail transit systems, with completely new lines for modern, fast trains (as in France and Italy) or extensions of

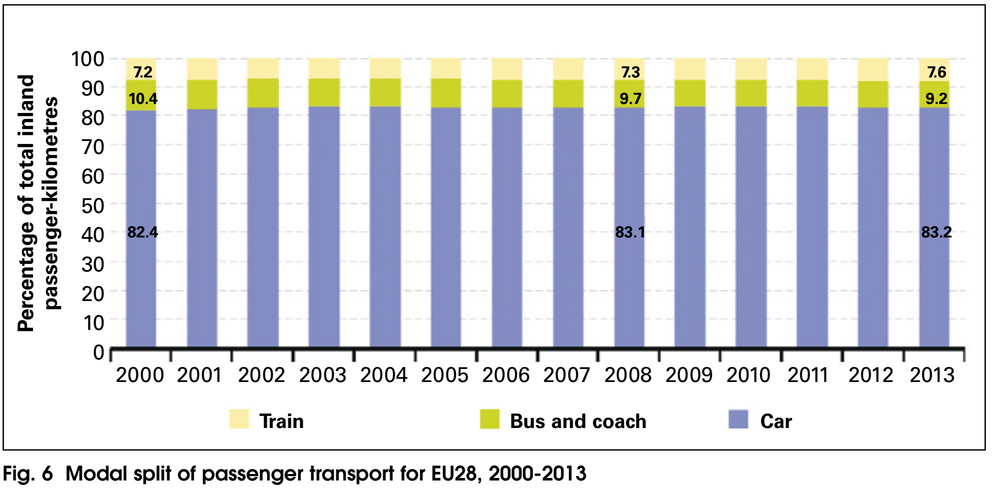

Fig. 6 Modal split of passenger transport for EU28, 2000-2013

Source: Eurostat passenger transport statistics. *http://ec.europa.eu/eurostat/statistics-explained/index.php/Passenger_transport_statistics* existing lines (as in Germany) that had survived the dismantling of many services after the Second World War as mass motorisation took hold (see Fig. 8). Where a lower density of built environment or lack of financial resources do not justify rail infrastructure, rapid bus transit technology has proved to be effective in serving urban development around transit facilities. Improvement in bus systems and services has been interpreted in different ways across Europe, with the Trunk Network in Stockholm, the Quality Bus Corridor in the UK and Ireland, BHNS, Bus à Haut Niveau de Service in France, and Metrobus in Germany and Spain. However, all such systems are all referred to as 'bus with a high level of service' (BHLS) (Fig. 9).

4.1.2 'Smart growth'

The close relationship between land use and transport within attempts to deliver sustainable urban development has been explored by the 'smart growth' network of private, public and non-governmental partner organisations that are seeking to create smart growth in neighbourhoods, communities and regions across the United States. The American Planning Association says that 'compact, transit accessible, pedestrian oriented, mixed use development patterns and land reuse epitomize the application of the principles of smart growth'.[12]

12 *Policy Guide on Smart Growth*. American Planning Association, 2002. Updated 2012. **https://www.planning.org/policy/guides/adopted/smartgrowth.htm**

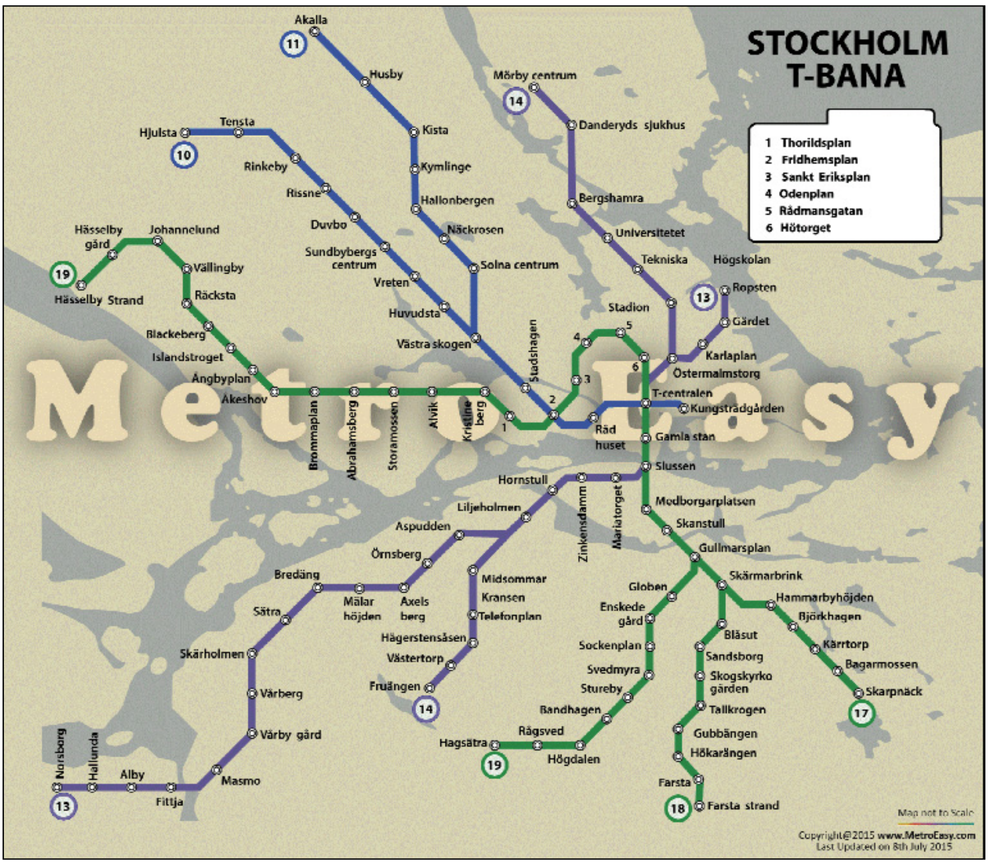

Fig. 7 Stockholm Tunnelbana
Source: Eurostat passenger transport statistics. ***http://metroeasy.metromates.com***

Fig. 8 Freiburg tramway network

Source: Wikimedia Commons. ***http://commons.wikimedia.org/wiki/File:Strassenbahn_Freiburg.svg#/***

Fig. 9 High-level bus service provision in Lorient, France

Some examples of how to adopt smart growth principles that have a clear impact on transport energy savings and GHG reduction include the following:

- Provide financial incentives to encourage residents to live near where they work.
- Support zoning by building type, not by use, to promote mixed-use communities.
- Encourage developers to reduce off-street surface parking – large surface spaces between the street and the front door of homes or businesses not only represent inefficient use of valuable urban land but also undermine the walkability that compact communities would otherwise support.
- Set the right price for street parking and use the revenues raised to pay for alternative local transport services, and remove minimum parking requirements.
- Use density bonuses to encourage developers to increase floor-to-area ratio.
- Concentrate critical services near homes, jobs and public transport – developments or communities that have medium-high densities and mixed land uses bring origins and destinations closer together and provide more incentives for people to walk.
- Require building design that makes commercial areas more walkable – diverse streetscapes with retail shops, restaurants, public art and other amenities encourage people to linger.
- Adopt design standards for streets that ensure safety and mobility for pedestrian and non-motorised modes of transport – short blocks, narrow widths, landscaping, on-street parking, through streets and walkways lead to streets that balance the needs of different transport modes.
- Adopt design standards for footpaths – these include adequate widths, buffers, continuity, connectivity and edges to ensure that they meet the needs of pedestrians.
- Require traffic-calming techniques where traffic speed through residential and urban neighbourhoods is excessive – these reduce speed, accidents and energy consumption, and return the street to all users (cyclists, walkers, drivers and users of public transport).
- Provide incentives for multi-modal transportation systems by including a commitment for follow-up implementation funds for the transportation elements of the plan.
- Connect transportation modes – every transit trip starts and/or ends with walking, and bike racks at public transport stations create a wider ridership for these systems by effectively extending the range that passengers can travel.
- Ensure good accessibility to public transport by clustering higher-density residential development around stops.

The last two measures encompass the concept of 'transit-oriented development', which is described in the following section.

4.1.3 Transit-oriented development (TOD)

Sustainability advocates tend to seek higher urban density for various reasons; one of the most important of which is to improve the efficiency of public transport. However, Paul Mees argues that thinking only in terms of average urban density might lead to distorted conclusions.[13] For instance, while the population density of the metropolitan area of Los Angeles is one-third higher than that of New York, transit mode share is one-fifth lower. Actually, what matters for public transport use is the density around stations and stops in the system, not average urban density. Greater Los Angeles has a huge population living at medium densities, with almost nobody living at the highest densities (see Fig. 10), while New York has a much broader distribution, with significant numbers living at the extreme densities of Manhattan (see Fig. 10).

13 P. Mees: *Transport for Suburbia: Beyond the Automobile Age*. Earthscan, 2010

Anthony Quintano.
https://www.flickr.com/photos/quintanomedia/
Attribution 2.0 Generic (CC BY 2.0)

DaveofCali at en.wikipedia
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(CC BY-SA 2.5)

Fig. 10 Compact building design in New York (left), and low densities in Los Angeles (right)

This is central to the concept of TOD, which argues that 'locating new construction and redevelopment in and around transit nodes is viewed by many as a promising tool for curbing sprawl and the automobile dependence it spawns'.[14] Peter Calthorpe defines TOD as 'a mixed-use community within an average 2000 foot [about 600 metre] walking distance of a transit stop and core commercial area'.[15] The basic idea of TOD is that a proper combination of accessibility to public transport, well connected walking and cycling networks and park-and-ride facilities can induce smart urban growth towards a liveable community.

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14 *Transit-oriented Development in the United States: Experiences, Challenges, and Prospects*. TCRP Report 102. Transportation Research Board of the National Academies, Washington, USA, 2004. **http://onlinepubs.trb.org/onlinepubs/tcrp/tcrp_rpt_102.pdf**

15 P. Calthorpe: *The Next American Metropolis: Ecology, Community and the American Dream*. Princeton Architectural Press, 1993

The high cost of free parking in the USA

Shoup[i] argues that free parking contributes to car dependence, urban sprawl, and excessive energy use. Free kerb parking and high levels of off-street parking for every land use distort transport choices, degrade urban design, damage the economy and harm the environment. Furthermore, failing to take account of the true costs of parking means that these hidden costs lead to higher prices for everything else. Shoup suggests three basic reforms: set the right price for kerb parking; use the parking revenue to pay for local public services; and remove minimum parking requirements.

i D. Shoup: *The High Cost of Free Parking*. American Planning Association, 2011

Density bonus at Faenza (Italy)

Density bonuses can promote many 'smart growth' features in communities, while also creating the land use intensity that more efficiently supports public services. For example, the Municipality of Faenza in Italy has implemented a 'bio-neighbourhood' incentive programme for developers, which is included in town planning regulations. The programme aims to achieve energy savings, promote the aesthetic qualities of neighbourhoods, and create better microclimatic conditions to prepare for the rising temperatures associated with future climate change. The incentive programme allows developers to extend the area of buildings in 'bio-neighbourhoods' in excess of approved standards if the buildings meet certain environmental sustainability criteria, such as green roofs, green walls and water retention systems, and the creation of public green spaces.

ABC location policy

In the Netherlands a special instrument has been developed to control land use in relation to transport infrastructure: the ABC location policy. It was introduced in 1989 to promote the concept of 'the right business in the right place'.

The ABC location policy is founded on the terms 'mobility' and 'accessibility'. Businesses and services attract traffic. The location of an office or service facility is an important factor influencing the amount of traffic generated by that facility. An office situated next to a railway station, for example, will more readily attract commuters by train, while an office located next to a motorway will encourage car use. Physical planning can influence the location of new offices; planning regulations also contribute.

Of course, each company has different transport needs. A university needs to be accessible by public transport and bicycles, while a distribution centre should be properly accessible by freight vehicles. To identify these different needs, under the ABC location policy planners draw up mobility profiles for various types of companies. Locations are classified according to their accessibility profiles, which indicate the accessibility of a location by public transport and by car.

The policy distinguishes between three types of locations, by accessibility:
- primarily by public transport (A-locations);
- by public transport and car (B-locations); and
- primarily by car (C-locations).

The mobility profile is the counterpart of the accessibility profile; the relationship between the two types of profile is one of supply and demand. Companies with a certain mobility profile are directed into a location with a matching accessibility profile. In drawing up a mobility profile, attention is paid to the number of employees in a company in comparison with the surface area of the company's facilities, the degree of the company's dependence on motorised transport in conducting its business, the number of visitors the company attracts, and its reliance on road haulage.

A-locations are accessible chiefly by public transport; thus they are principally suitable for businesses that employ or otherwise attract many people come. These include businesses and services with the following mobility profile:
- many employees in comparison with available surface area and/or attracting a large number of visitors;
- low business-related car use; and
- low goods transportation.

B-locations are reachable both by car and by public transport. The mobility profile of suitable businesses are those that have:
- moderate labour and/or visitor intensity;
- moderate car dependency; and
- moderate dependency on road haulage of goods.

C-locations are easily accessible by car. These are suitable for businesses with the following mobility profile:
- relatively low number of employees and visitors; and
- strongly dependent on motorised transport for goods and/or people.

Fig. 11 Urban development around a tramway line in Freiburg, Germany

4.2 Transport energy consumption and urban form

In recent years a great number of studies, particularly in Western European and North American cities, have concluded that urban form and land use characteristics affect travel choices and are the primary influence on the amount that people drive. Energy consumption related to transport is an interesting indicator of mobility behaviour because it aggregates several features: trip frequency, travel distance, transport mode choice, vehicle occupancy rates, and power train efficiency.

Many studies indicate the existence of a negative correlation between private transport energy consumption (fuel use) and urban density (see Fig. 12).[16] Karathodorou *et al.* found that increasing urban density by 10% reduces fuel consumption per capita by 3.4%, car ownership by 1.2% and the annual distance driven by car by 2.3%.[17] Other research has found a negative correlation between urban density and travel behaviour in terms of total car mileage and car share, and a positive correlation with the share of walking and cycling.[18]

An analysis of average density is not sufficient to explain the relationship between the structure of a city and transport energy consumption. In particular, factors such as the relative location of residents, workplaces, services and amenities, transport options and network connectivity have a significant impact on the number and length of trips. Bertaud has argued that the density gradient – i.e. the rate of density change from the centre to the periphery – is a more important determinant of transport energy and the urban spatial structure (see Fig. 13).[19] Public transport is incompatible with low-density

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16 J.R. Kenworthy and F.B. Laube: 'Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy'. *Transportation Research Part A: Policy & Practice*, 1999, Vol. 33, 691-723

17 N. Karathodorou, D.J. Graham and R.B. Noland: 'Estimating the effect of urban density on fuel demand'. *Energy Economics*, 2010, Vol. 32 (1), 86-92

18 P. van de Covering and T. Schwanen: 'Re-evaluating the impact of urban form on travel patterns in Europe and North America'. *Transport Policy*, 2006, Vol. 13, 229-39

19 A. Bertaud: *Metropolis: A Measure of the Spatial Organization of 7 Large Cities*. 2001. **http://alainbertaud.com/wp-content/uploads/2013/06/AB_Metropolis_Spatial_Organization.pdf**

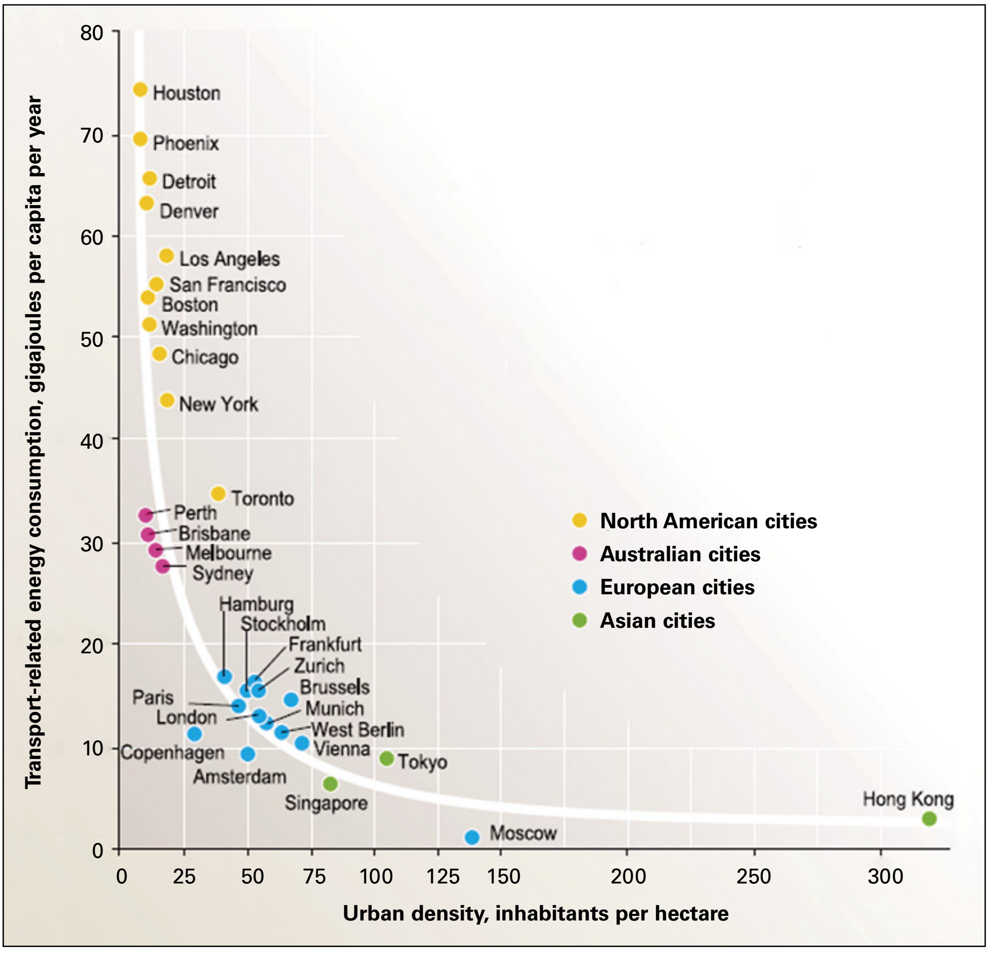

Fig. 12 Urban density and transport-related energy consumption
Source: J.R. Kenworthy and F.B. Laube: 'Patterns of automobile dependence in cities: an international overview of key physical and economic dimensions with some implications for urban policy'. *Transportation Research Part A*, 1999, Vol. 33, 691-723

and dominantly polycentric urban structures (see Fig. 14). Investment in public transport infrastructure is sustainable if housing and employment density is sufficient within the catchment area of transit stops (800 metres or a 10-minute walk).[20] Other research supports the finding that dense and moderately polycentric cities are compatible with an effective public transport system.[21]

4.3 The urban transport energy dependence model

Although transport energy use is a direct outcome of land use distribution and transport system efficiency, the issue is not part of current transport and urban planning practice. There is broad, although not universal, consensus that increasing

20 B. Lefevre: 'Urban transport energy consumption: determinants and strategies for its reduction'. *S.A.P.I.EN.S.*, 2009, Vol. 2 (3). **https://sapiens.revues.org/pdf/914**

21 A. Bertaud and S. Malpezzi: *The Spatial Distribution of Population in 48 World Cities: Implications for Economies in Transition*. Center for Urban Land Economics Research, University of Wisconsin, Madison, USA, 2003. **http://alain-bertaud.com/AB_Files/Spatia_%20Distribution_of_Pop_%2050_%20Cities.pdf**

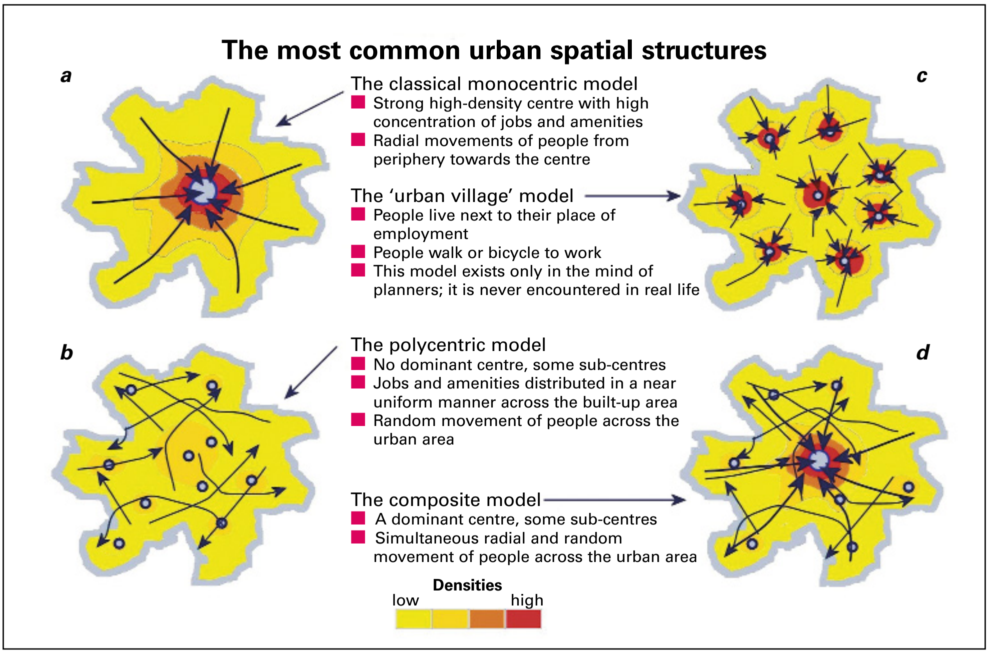

Fig. 13 Urban spatial structures and mobility patterns

Source: A. Bertaud: *Metropolis: A measure of the spatial organization of 7 large cities.* 2001. Available at http://alain-bertaud.com

urban density is beneficial for reducing the distance that people travel by private car, and consequent energy consumption. Statistical models can be found in technical literature demonstrating a strong correlation between urban density and fuel consumption. Nevertheless, these results are of little use in urban and transport planning practice because transport energy consumption is also influenced by many other variables, such as fuel price, car ownership, the level and quality of public transport, provision for walking and cycling, travel choice behaviour, standard emissions of circulating vehicles, and so on.

The authors of this paper[22] have developed a land use, transport and energy model to incorporate transport energy into urban planning (see Fig. 15).[23] The model calculates a city's so-called 'transport energy dependence' (TED) – i.e. the minimum amount of energy that a city would require for transport if land use locations and transport choices were optimised. This requires every citizen to live as close as they can to their workplace and chooses the most energy-efficient mode of transport consistent with the distance to be travelled.

TED can be thought of as a minimum transport energy performance standard, i.e. a specification or minimum requirement for the approval of urban and transport plans. The standard could be applied both at the urban and neighbourhood scales. It is expressed in terms of the amount of energy per person needed in the ideal scenario

22 G. Inturri, M. Ignaccolo, M. Le Pira, V. Mancuso and S. Caprì: 'Analysis of land use and mobility scenarios for the reduction of transport energy in the urban area of Catania'. International Conference on Traffic and Transport Engineering, Belgrade, Nov. 2014 . **http://www.academia.edu/10137715/ANALYSIS_OF_LAND_USE_AND_MOBILITY_SCENARIOS_FOR_THE_REDUCTION_OF_TRANSPORT_ENERGY_IN_THE_URBAN_AREA_OF_CATANIA**

23 This work was based on M. Saunders, T. Kuhnimhof, B. Chlond and A. Rodrigues da Silva: 'Incorporating transport energy into urban planning'. *Transportation Research Part A: Policy & Practice*, 2008, Vol. 2 (6), 874-82

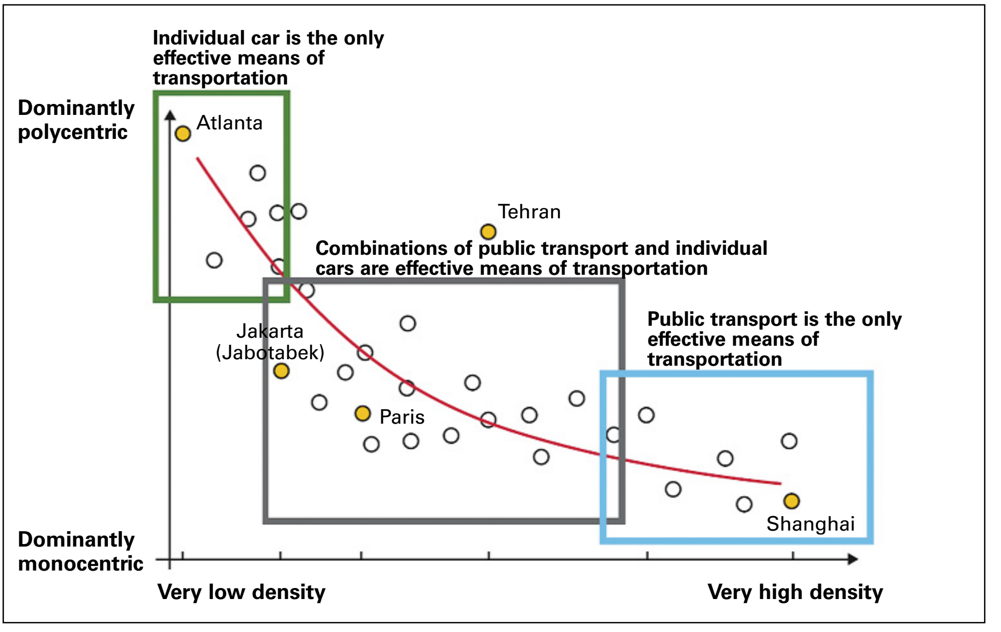

Fig. 14 Relationship between spatial structure and the effectiveness of public transport

Source: A. Bertaud and S. Malpezzi: *The Spatial Distribution of Population in 48 World Cities: Implications for Economies in Transition*. University of Wisconsin, 2003.
http://alain-bertaud.com/AB_Files/Spatia_%20Distribution_of_Pop_%2050_%20Cities.pdf

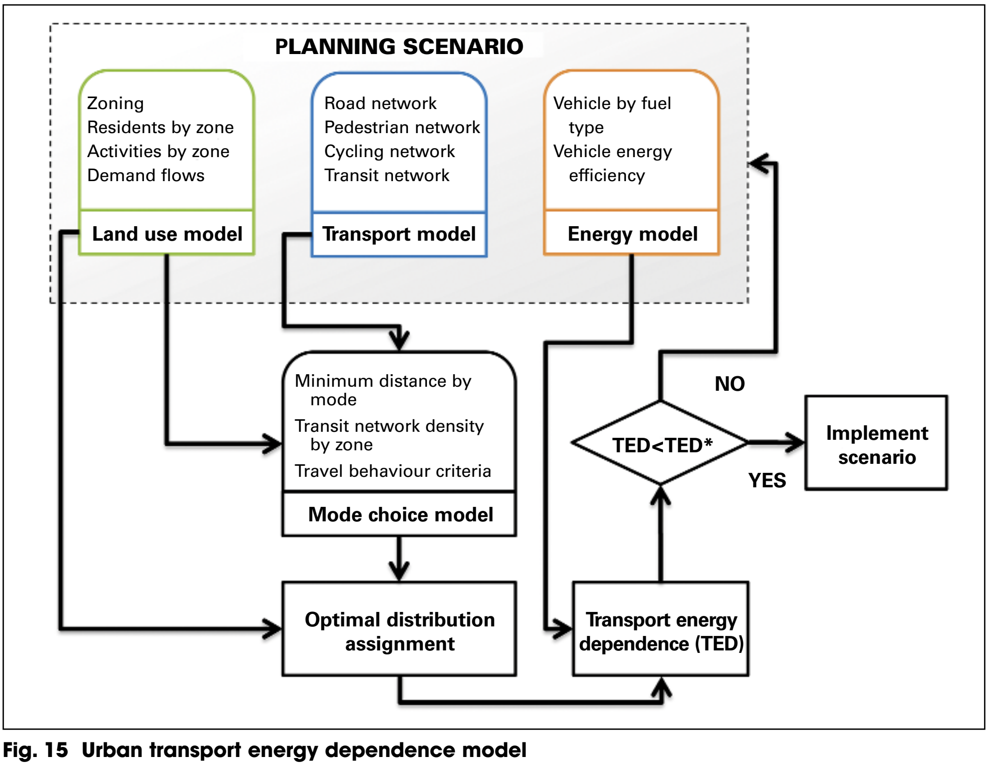

Fig. 15 Urban transport energy dependence model

G. Inturri, M. Ignaccolo, M. Le Pira, V. Mancuso and S. Caprì: 'Analysis of land use and mobility scenarios for the reduction of transport energy in the urban area of Catania'. International Conference on Traffic and Transport Engineering, Belgrade, Nov. 2014 . http://www.academia.edu/10137715/ANALYSIS_OF_LAND_USE_AND_MOBILITY_SCENARIOS_FOR_THE_REDUCTION_OF_TRANSPORT_ENERGY_IN_THE_URBAN_AREA_OF_CATANIA in which the land use mix and transport options are such that jobs are as close to home as possible for everyone in employment, with the choice of travel mode based only on the distance to be covered from home to work.

The model is based on a mathematical description of the road and transport networks and commuting demand flows in an urban area. Commuters choose their transport mode according to a set of simple rules based on distance from home to work and the density of the public transport network. Optimal commuter flows are assigned between home zones and work zones to minimise transport energy use for the transport modes used. The energy consumption model is based on the energy efficiency of each vehicle, its capacity and the load factor. The methodology helps in achieving a number of different aims:

- evaluating the potential impact of changes in land use, transport and vehicle technology policies in terms of transport energy consumption;
- defining a baseline transport energy consumption for evaluation of the energy actually used for transport; and
- defining the transport energy requirements for the approval of land use and transport plans.

The model has been tested in the urban area of Catania, Italy, to estimate the impact of the measures within urban land use and mobility plans currently under discussion.

5 Case studies

This Section sets out three case studies:

- the City of Judenburg's Sustainable Urban Mobility Plan (Styria, Austria);
- Catania's first bus rapid transit system (City of Catania, Italy); and
- the Bicike(LJ) bike-sharing system (Ljubljana, Slovenia).

5.1 Sustainable Urban Mobility Plan – Judenburg, Austria

5.1.1 Context and background

Judenburg is located in the State of Styria and is the regional capital of the district of Murtal. It is densely populated, with about 9,300 inhabitants within an area of 13 square kilometres. Although its heavy industry sector collapsed in the early 1980s, the city is now once again home to well known industrial companies such as the steelmaker Stahl Judenburg. A few years ago, the city started to intensify investments in sustainable urban transport, investing, for example, in services such as the Citybus (inner-city buses) and the Verkehrsverbund Aichfeld (regional public transport). In 2010, the city prepared a new local transport plan. Despite these efforts, traffic-related emissions and the number of trips made by car continued to rise. The scope of the city's powers are limited, and it does not have the legal competence to act across all the relevant fields.

As part of the EU project ADVANCE, the research, consulting and educational non-profit company AMOR, based in Graz, developed and applied an audit scheme for SUMPs (Sustainable Urban Mobility Plans). The ADVANCE audit compares a city's transport planning to an ideal sustainable urban mobility planning process. One of the cities that piloted the audit is Judenburg in the Province of Styria.

5.1.2 Objectives, implementation measures and financing

The ADVANCE audit has proved to be a practical tool for improving SUMPs in cities and municipalities. It provides a systematic evaluation method and guidance, indicates ways of making SUMPs more effective, and provides added value to cities. The main tool of the ADVANCE audit is the self-assessment questionnaire, which is completed by the members of the ADVANCE working group (made up of city representatives and internal stakeholders). The audit is facilitated and moderated by the ADVANCE auditor.

From April to September 2013 the City of Judenburg undertook the ADVANCE audit. Eight representatives of the City of Judenburg and surrounding municipalities, together with two external auditors, formed the ADVANCE working group, which met six times. The main activities were the introduction of the ADVANCE methodology, an assessment of the quality of mobility planning in Judenburg, and a site visit to assess the situation on the ground. Key milestones of the ADVANCE audit process in Judenburg were:

- an analysis of the existing situation;
- an assessment (self-assessment by city representatives using a standardised questionnaire);
- prioritisation (based on discussion of the results of the questionnaire, building consensus, and prioritising actions and addressing gaps);
- the preparation of the final action plan (including improvement measures and concrete recommendations); and
- an audit report and certification system (presentation of the action plan to Judenburg's political committees, and a certification process).

Many cities are currently having to manage with decreasing financial resources. With this in mind, the selection of actions prioritised cheap measures that could be easily implemented by city staff.

5.1.3 Results

The output of the audit is the action plan, ADVANCE Massnahmenplan, which gives detailed information about the measures that need to be implemented to improve sustainable urban mobility planning in Judenburg. The action plan contains a detailed description of 33 process and action measures based on the results of the audit process and developed in close co-operation with the working group members. In addition, these measures have been presented to the Mayor of Judenburg.

The prioritisation process has resulted in high importance being given to the improvement of process measures. The recommendations for the City of Judenburg include:

- an annual budget for investment in public transport;
- better information for Judenburg's citizens about mobility measures;
- the introduction of a local mobility co-ordinator;
- the implementation of a study on increasing the performance of the inner-city buses (including a passenger survey);
- improvements in the interface between the inner-city bus network and regional/national rail; and
- the promotion of cycling tourism.

5.1.4 Key lessons

A number of key lessons can be drawn from the Judenburg experience:

- Although the concept of Sustainable Urban Mobility Plans is well known and accepted in some countries such as France and the UK, it is new for the majority of EU countries.
- The ADVANCE audit scheme provides a guided tool to start or further the process of sustainable urban mobility planning in cities.
- An external auditor is important as he/she brings a fresh perspective.
- The size of the working group for conducting the audit should not exceed 15 people.
- The audit includes four to five meetings of the working group – it is important that the group participate in the whole process, otherwise the discussion will be fragmented.

5.2 Bus Rapid Transit – Catania, Italy

In April 2013 Catania, in Southern Italy, saw the inauguration of its first bus rapid transit (BRT) line, operated by AMT Spa, the metropolitan public transport company. The Department of Environmental and Civil Engineering of the University of Catania was a scientific and technical partner of the Municipality of Catania for the planning and implementation of the project.

5.2.1 Context and background

The city of Catania has about 300,000 inhabitants, with 750,000 in the wider metropolitan area. Since the 1970s the city has been losing population due to urban development policies that have encouraged urban sprawl, thus implicitly promoting the use of the private car and increasing traffic congestion. Catania has one of the highest car ownership rates in Italy, equal to 0.7 cars per inhabitant (compared with 0.6 in Italy and 0.45 in Europe as a whole). During the morning peak period there are almost inbound 60,000 trips and 7,000 outbound. The modal share of public transport is 13% of the total kilometres travelled. Levels of walking and cycling are low, mainly due to the amount of urban spaces occupied by cars.

AMT operates 50 bus lines, covering approximately 40% of the city road network, with a low average frequency or headway (23 minutes in the peak period). Annually it runs services over a distance of 11 million kilometres and transports 30 million passengers. Although a set of park-and-ride facilities have been built around the city, the high level of car traffic strongly affects AMT's ability to provide a competitive public transport service compared with the private car.

Long-term transport planning is providing substantial improvement of the metropolitan system, with the completion of the subway line serving the east-west corridor and the transformation of the railway line into a high-frequency regional service in the north-south corridor. But given the long time needed for the construction of rail systems, in 2011 the Municipality of Catania asked the University of Catania to prepare a short-term transport plan (the Urban Traffic Plan), which would include pilot projects to help promote a change in citizens' choice of transport mode. The BRT line was one of these pilot projects. Its objectives were to:

- demonstrate that public transport can be competitive with the car and that the modal shift can be increased;
- build a feasible cost-effective transit line in a short time;
- reduce the volume of cars accessing the city by providing a park-and-ride system; and
- increase the passenger occupancy of cars accessing the park-and-ride facility.

5.2.2 Implementation measures and results

Rail transit systems are not technologically superior per se when compared with rubber-tyred highway transit. The most critical element to their superior performance when compared with conventional bus networks is that rail systems generally have 'right of way'. With this in mind, the University suggested a BRT system with a high percentage of protected running way, separated from cars and possibly with separated grades to avoid intersections. Extensively used in many parts of the world, BRT is proving to be a cost-effective transportation mode that bridges the capital cost gap between a regular bus service and light rail transit, with the ability to deliver services with features that are normally only found in rail services.

The Urban Traffic Plan of Catania includes a BRT network of four lines as the main backbone of the whole transit bus network. They are integrated with the existing rail systems (subway and railway) and with those under construction, and with the park-and-ride facilities (see Fig. 16).

The first line – BRT1 (see Fig. 17) – is already in operation as a pilot project. It is 12.8 kilometres long, with 18 stops, and links the park-and-ride facility Due Obelischi in the north with the city centre (Stesicoro). It was given high priority because the main car flows congesting the city are in the north-south corridor. The running way is protected by a rubber kerb for most of its path (or has been painted). The distance between stops is much wider than for standard bus routes. All stops are provided with shelter and real-time information on expected waiting times, all main road intersections are equipped with traffic lights giving priority to BRT, and the vehicles have a distinctive design to distinguish the BRT line from standard public transport. A dedicated fare system has been adopted to encourage more people to car share and then leave their vehicle at the park-and-ride facility (ranging from €1 to €1.50 per person for a round trip ticket, based on the number of people inside the car – the car parking is free).

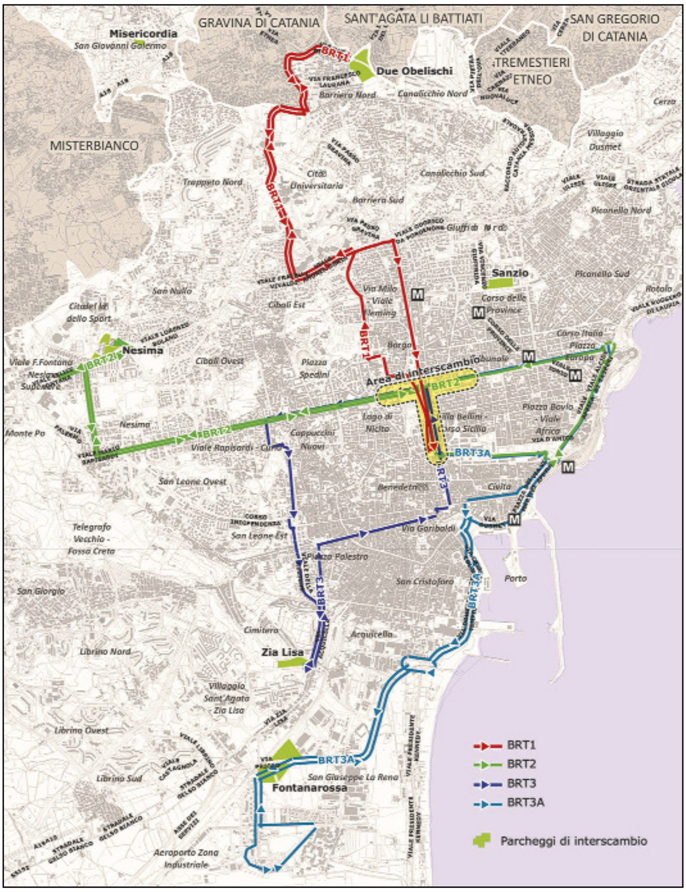

Fig. 16 Planned BRT network for Catania

Source: PGTU Catania

The ticket is integrated with one of the subway lines, which operates with a seven minute frequency from 7.00 am to 2.30 pm, ten minutes up to 9.00 pm, and 15 minutes up to midnight. The travel time from the terminus to the city centre is around 18 minutes, and the journey speed is more than 21 kilometres per hour (a third higher than on other lines). The ridership is about 5,000 passengers per day, and 600 cars are parked at the park-and-ride facility.

The main outcomes from the pilot are:

- The image of public transport in Catania has fundamentally changed, and people now want the entire BRT network to be built.
- For the first time in Catania it is reported that users are choosing to use public transport rather than their cars.
- The ridership of 5,000 passengers per day is the highest of all the network lines, and it is estimated that one-third of these passengers were using the car before the new line opened.
- It is estimated that the investment in public transport will lead to a significant reduction in carbon dioxide emissions – of around 800 tonnes per year.

5.2.3 Key lessons

A fast, economic, concrete and operational pilot project, such as the BRT line, can be the most effective way to demonstrate that a radical change in transport policy is possible. It can facilitate and support the emergence of a coalition of stakeholders who want positive change. The design and building of a single transit line project

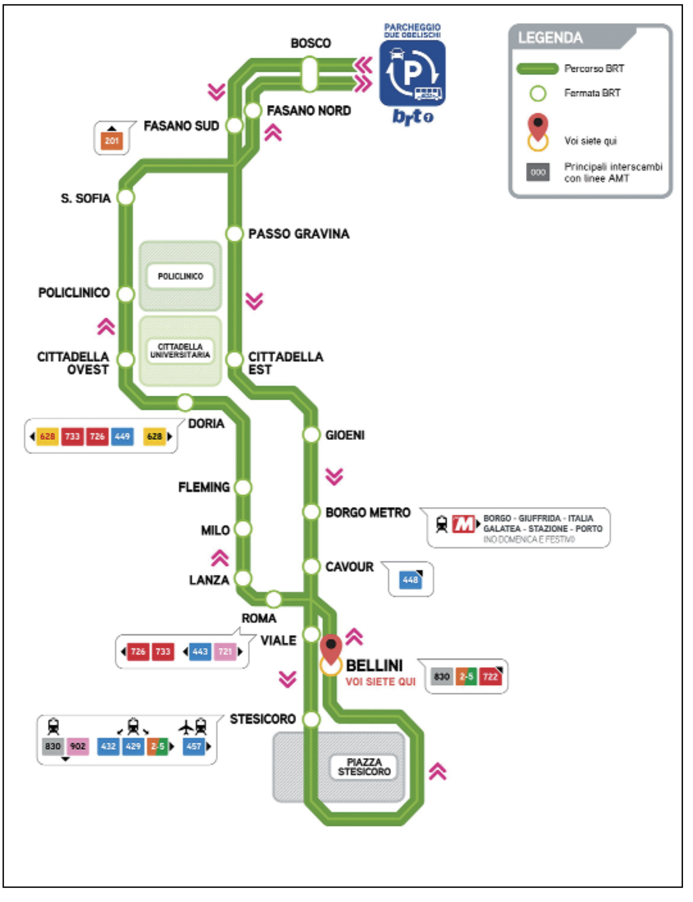

Fig. 17 BRT1 route and connections

Source: Bus Rapido Catania. http://www.brtcatania.it

can be a multiplier for several other demonstration transport planning measures, such as:

- parking pricing and management – removing on-street parking along the route, making the park-and-ride facility free of charge, and reducing the fare for town centre destinations;
- introducing intelligent transport systems – pre-emptive traffic lights activated by the transit vehicle approaching the intersection, and electronic stop displays showing real-time information on the service; and
- improving the walking infrastructure so that people can easily access public transport stops.

5.3 Bicike(LJ) bike-sharing system – Ljubljana, Slovenia

The Bicike(LJ) bike-sharing system was launched in the City of Ljubljana in 2011 and now comprises 36 stands and 360 bicycles. It is an excellent example of effectively establishing infrastructure with the goals of reducing harmful traffic emissions, improving air quality, and facilitating quick and easy access around the city.

The Municipality of Ljubljana, as public partner in the project, provided optical and electrical infrastructure at the stations, made available locations for outdoor advertising, and shared the costs. Europlakat, as private partner in the project, provided system construction and management and outdoor advertising, and also shared the costs.

5.3.1 Context and background

Designed for short journeys averaging around 20 minutes, the Bicike(LJ) system enables users to get from one station to another rapidly. It offers city dwellers an alternative to the systematic use of a car for short journeys, and so helps to reduce carbon dioxide emissions. The system uses the Urbana city card, which operates across public transport services in Ljubljana. It is also the membership card for public libraries and can be used as a method of payment for most of the city's museums, galleries, and other cultural facilities and events.

Thanks to the public-private partnership that established the bike-sharing scheme, the costs for using a bike are low. A one-year subscription to Bicike(LJ) costs €3 and a week's subscription (mainly for tourists) costs €1. The first hour of rental is free, the second hour costs €1, the third €2, and each further hour €4. A user can rent another bike five minutes after returning the first one. Because bike stations are close to each other almost all rentals are concluded in less than an hour.

5.3.2 Results

After just one month of operation, the number of people using the Bicike(LJ) system was as high as in cities where similar schemes had been in effect for several years. Within one month there were over 13,000 users, with each bike used on average six times a day. The record number of bike rentals in a single day is 3,227, equating to almost 11 rides for each bike. The 611,218 journeys made by users in the first year exceeded all expectations, and the one-millionth journey was registered 17 months after setting up the system. The bikes are regularly used by 10% of Ljubljana's population.

So far, the system has 36 stations, 360 bikes and about 63,000 users, with about 28,500 of them being regular users with an active annual subscription. In a little over 3.5 years, the system recorded nearly 2.5 million bike rentals. Each of the 300 bikes is out on the road for at least two hours a day, with each loan lasting an average of 14 minutes.

According to research conducted in October 2012, in which 311 residents of Ljubljana and surrounding areas took part, the Bicike(LJ) project is rated as very beneficial by 79% of those surveyed and positive by 95%.

The council has received special recognition for implementing this project, including an Urban Visionary award in 2011.

5.3.3 Key lessons

A number of key lessons can be drawn from the Bicike(LJ) scheme:

- The Bicike(LJ) system is an excellent example of effectively establishing infrastructure with the goals of reducing harmful traffic emissions, improving air quality, and facilitating quick and easy access around the city.
- The introduction of Bicike(LJ) is helping Ljubljana to fulfil its vision as a cycle-friendly city, by offering residents and visitors a more environmentally- and people-friendly means of transport that replaces the use of private cars. The new City of Ljubljana transport policy sets a target of one-third of journeys being made by bike or on foot, one-third by public transport, and the rest by private vehicles by 2020.
- The project is also a great example of a successful public-private partnership, providing urban residents with responsible and quality service at an affordable price.

6 Conclusion

Achieving improvements in energy efficiency in transport planning is a key issue for urban sustainability; but the task is not an easy one. Land use and transport planning and the adoption of new vehicle technologies have to be integrated to avoid unnecessary travel, to shift travel to more efficient modes, and to improve the efficiency of vehicle and fuel technologies.

This Expert Paper has presented examples of a range of different actions – from planning and regulatory changes through to economic incentives, better information and technological improvements. While these initiatives depend to some extent on the urban context and the particular transport needs of citizens, the key lessons set out in are transferable across different cities.

SPECIAL Project – Spatial Planning and Energy for Communities In All Landscapes
SPECIAL Expert Paper 3: *Making the Connection – Energy, Transport and Urban Planning. An Integrated Approach to Improving the Energy Efficiency in Transport Systems*.
By Giuseppe Inturri and Matteo Ignaccolo

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Published by the Town and Country Planning Association, 2 March 2016

Co-funded by the Intelligent Energy Europe Programme of the European Union

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This Expert Paper is published by the Town and Country Planning Association as Lead Partner in the SPECIAL project. The TCPA gratefully acknowledges financial support from the Intelligent Energy Europe programme.