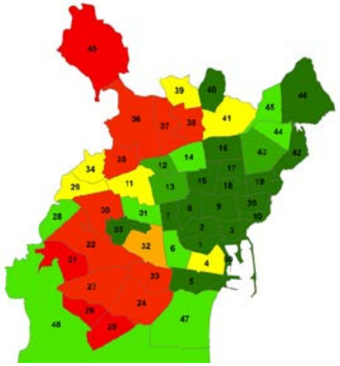
UNIVERSITÀ degli STUDI di CATANIA

SIET

XVII Conference of the Italian Association of Transport Economics and Logistics

New developments in transport economics: balancing economic growth, environmental sustainability and social inclusiveness

Bocconi University - Milan, 29th June - 1st July 2015



Integrating land use, transport and energy policies for sustainable urban areas

Inturri G., Ignaccolo M., Le Pira M., Mancuso V., Caprì S.

CeNSU Centro Nazionale Studi Urbanistici

University of Catania, Department of Civil Engineering and Architecture

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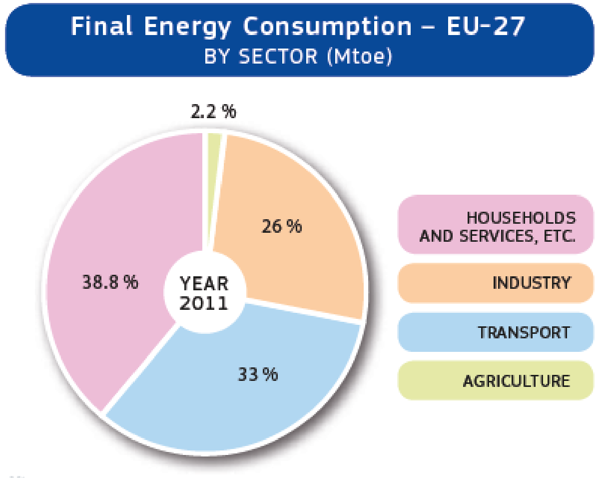
SPATIAL PLANNING and ENERGY for COMMUNITIES IN ALL LANDSCAPES

Research objectives

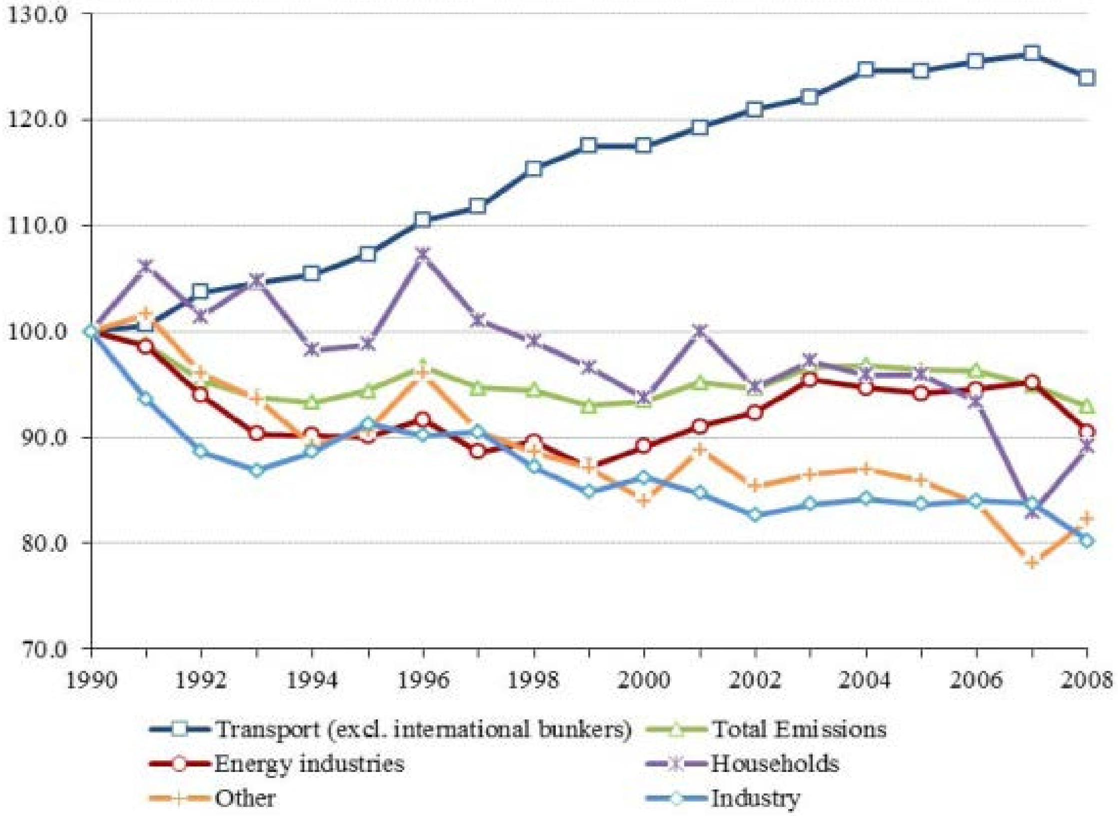
- Highlight the impact of transport on energy sustainability in urban areas and on EU targets on climate change
- Set up a methodology to calculate a transport energy indicator to support the delivery of sustainable land use and transport urban plans
- Test the methodology in a case study

Transport Energy impacts

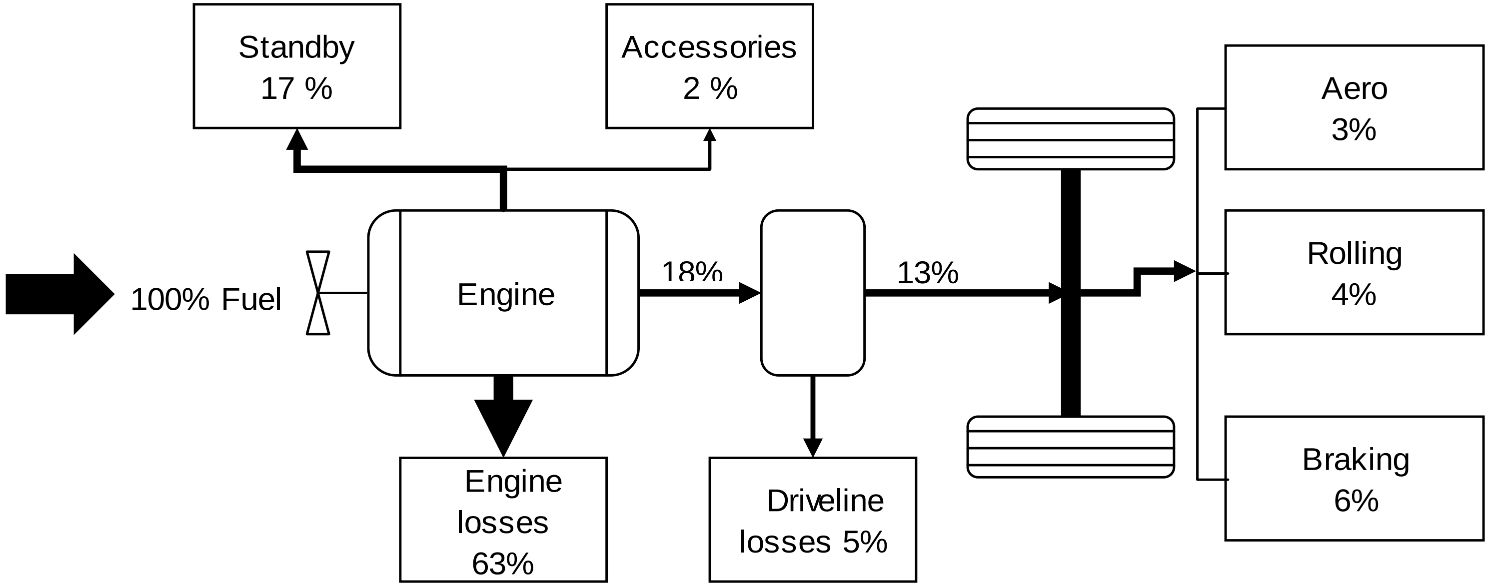
- 1/3 of energy
- 70% of oil
- 1/3 of CO_2 emissions
- 50% in urban areas
- 2.5% average traffic growth rate

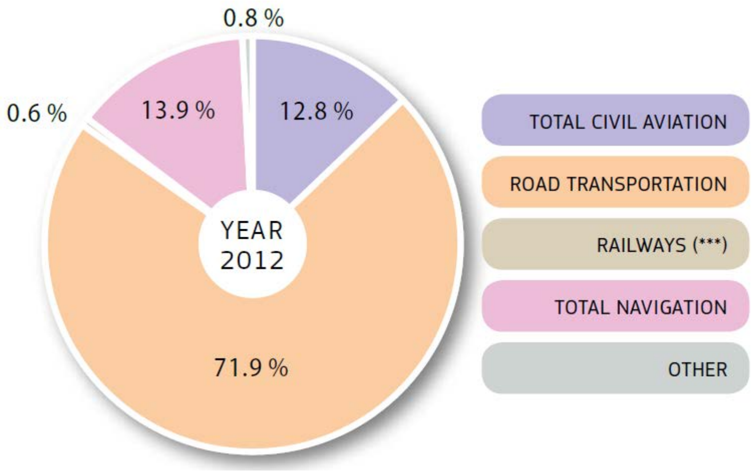


EU Energy and Transport in Figures St atistical Pocket book 2013



Transport Energy Efficiency

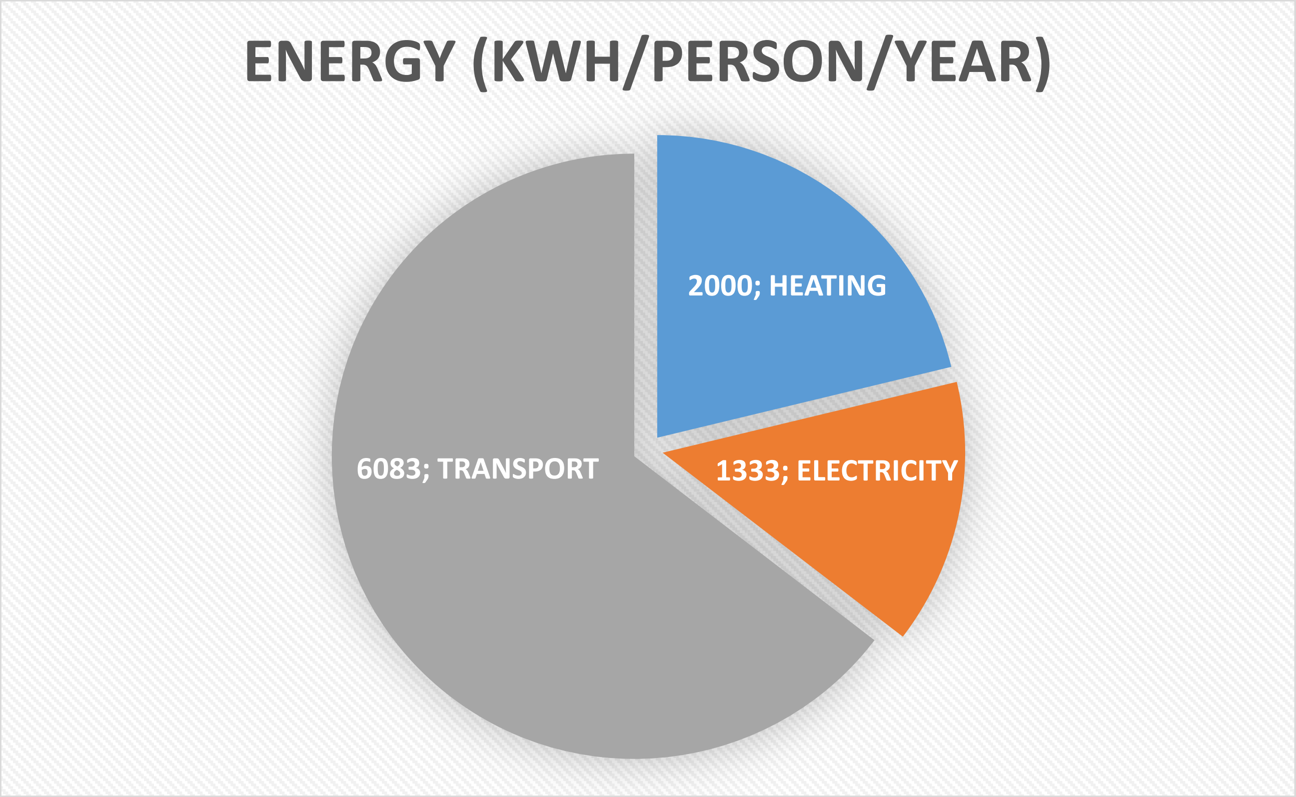


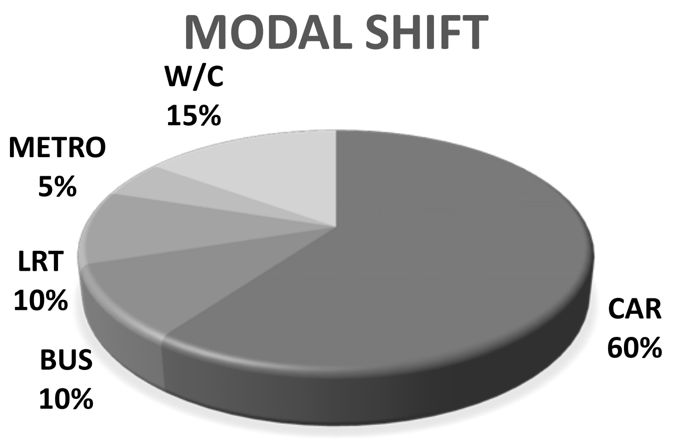


EU Energy and Transport in Figures
St atistical Pocket book 2013

INTRINSIC ENERGY INEFFICIENCY OF CARS
less than 2% of consumed energy is used by the payload

Urban Energy Demand

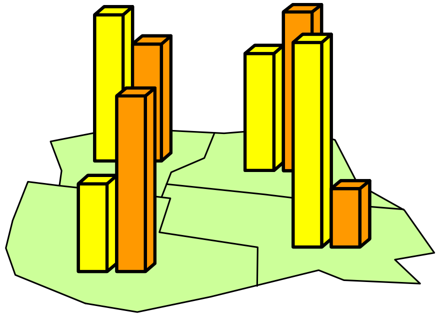




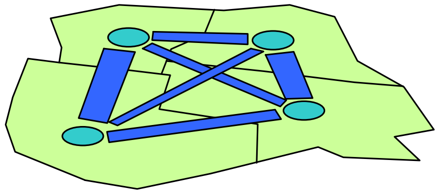
- 10.000 km/pers/year
- 100 kwh/year/mq (including cooling and lighting)
- Waste management and urban deliveries not included

http://www.passivhaushomes.co.uk/whatisph.html

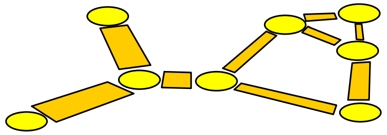
How to reduce urban transport energy demand



Land Use



Spatial Interactions



Transportation Network

Land Use Intensity

Energy Intensity

$$E_t[kWh] = \boxed{Persons\,[pax] \times Distance[km]} \times \frac{\boxed{Vehicle\_unit\_consumption\,[kWh/km]}}{\boxed{Vehicle\_capacity\,[pax] \times Load\_factor\,[\%]}}$$

Transport System Efficiency

Urban density and transport energy

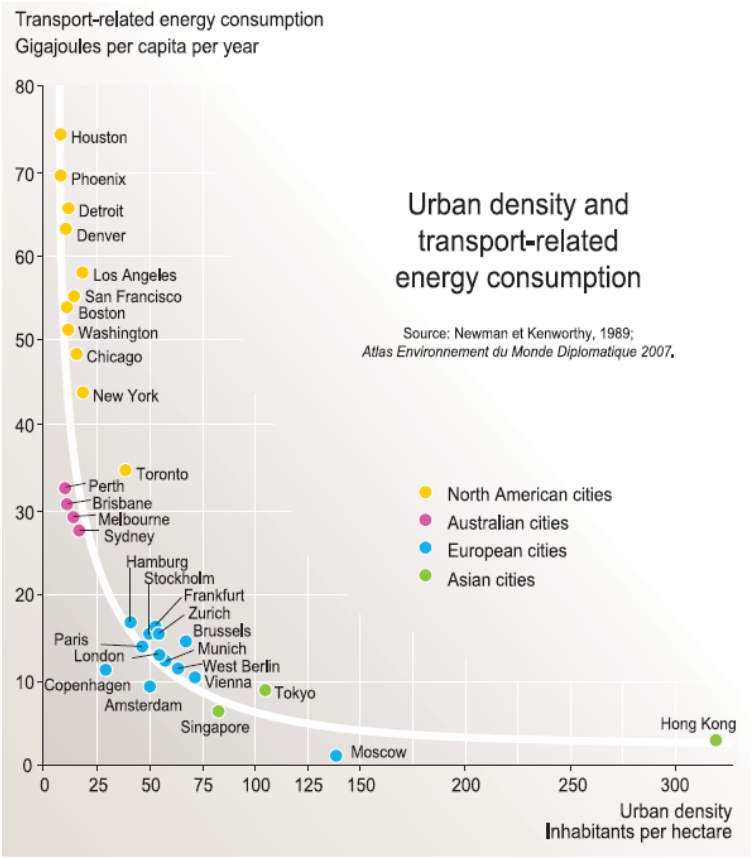


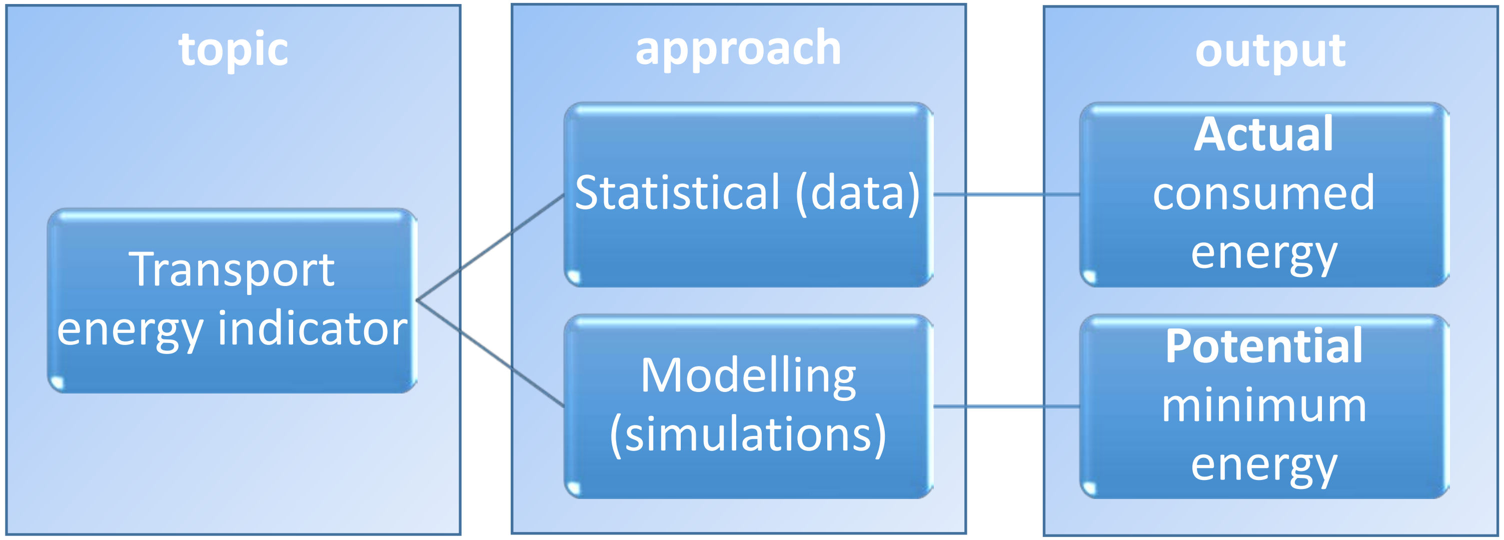
Figure 1 : The Newman and Kenworthy hyperbola: Urban density and transport-related energy consumption

literature

- High density and job-housing balance to reduce VMT (Marique and Reiter, 2012)
- Proximity home to work more important than mode choice (Boussaw and Witlox, 2009)
- Urban density affects fuel consumption mostly through variations in the car stocks and in the distances travelled more than fuel consumption per km (Karathodorou et al., 2010)
- Mindali (2004) found a weak correlation between density and energy consumption and questions the method of Newman and Kenworthy
- Spatial distribution and dynamics more important than average density (Bertaud, 2004)

- Most of these works use travel distance and travel mode taken from national statistical data

literature



indicator		output	reference
CEP	Commute-Energy Performance index	Actual energy	Boussauw and Witlox (2009)
IPE	Energy Performance Index	Actual energy	Reiter and Marique (2012)
TES	Transport Energy Specification	Ideal energy	Saunders et al. (2008)
TED	**Transport Energy Dependence**	**Ideal energy**	**Inturri et al. (2014)**

Average Density vs Spatial Dynamics

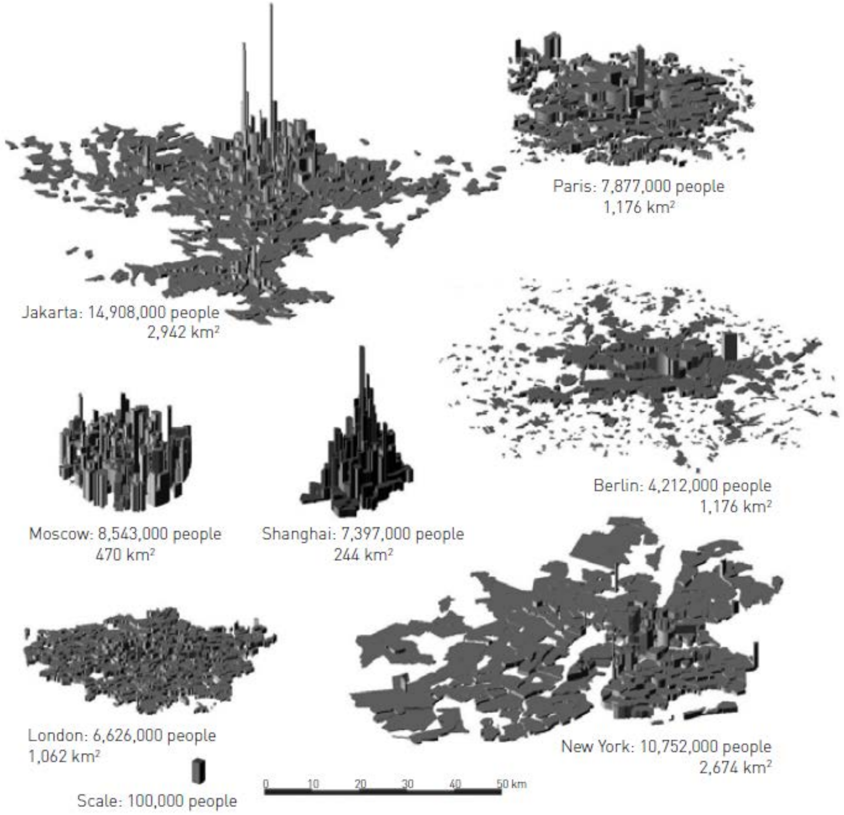
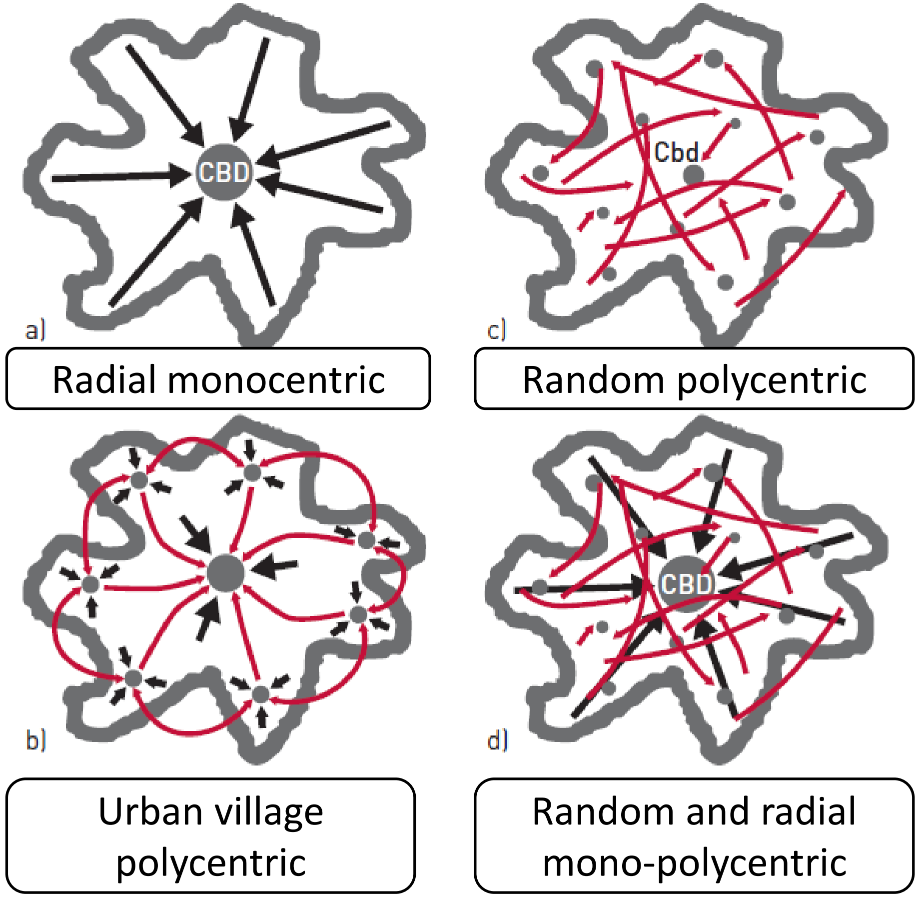
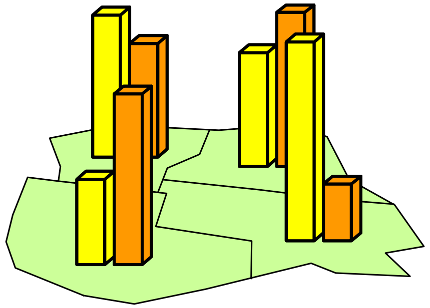


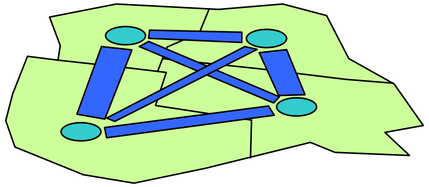
Figure 3. Residential density distribution in several cities. Source: (Bertaud, 2001).



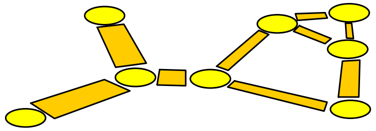
Land Use- Transport – Energy model



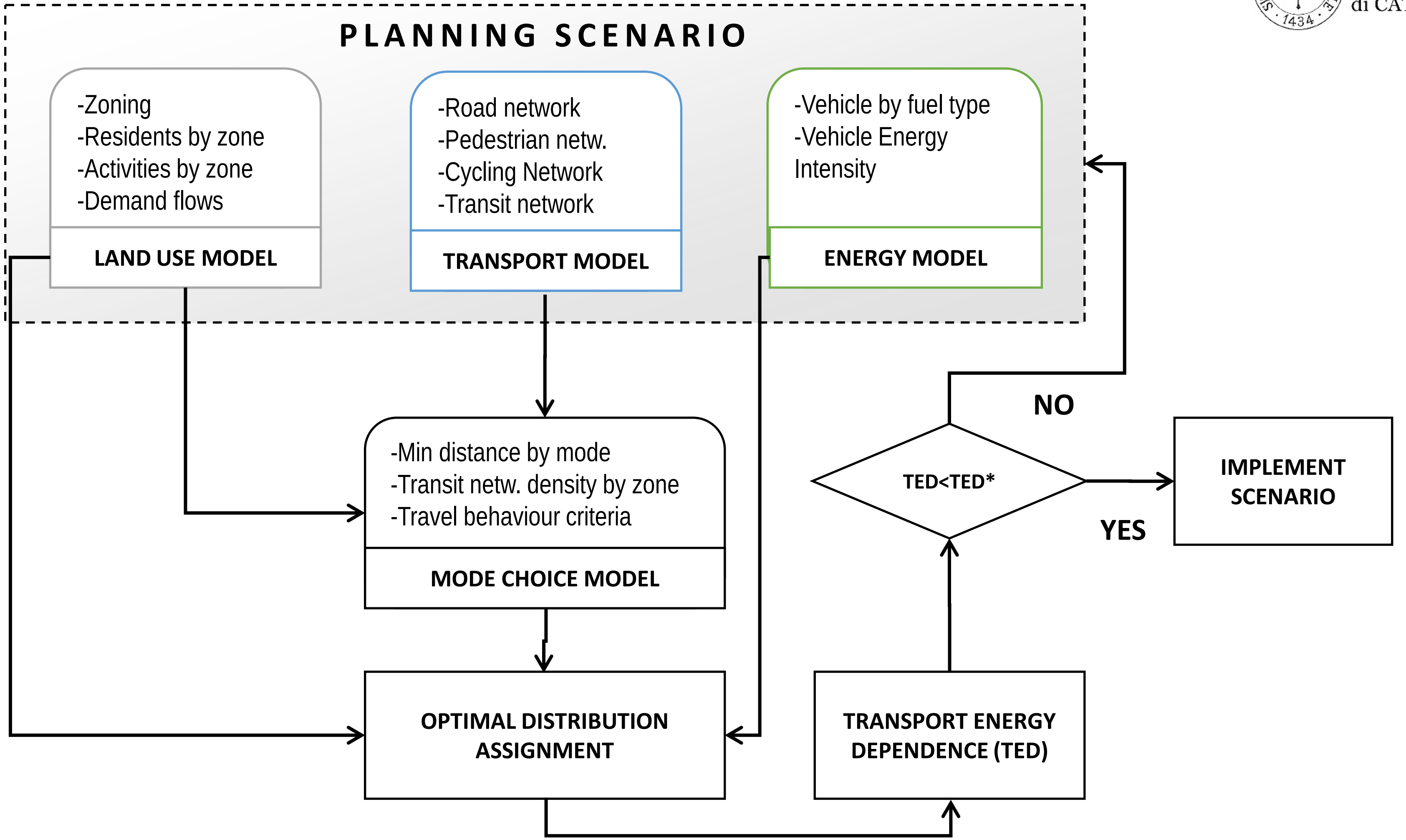
Land Use



Spatial Interactions



Transportation Network



Transport mode choice model

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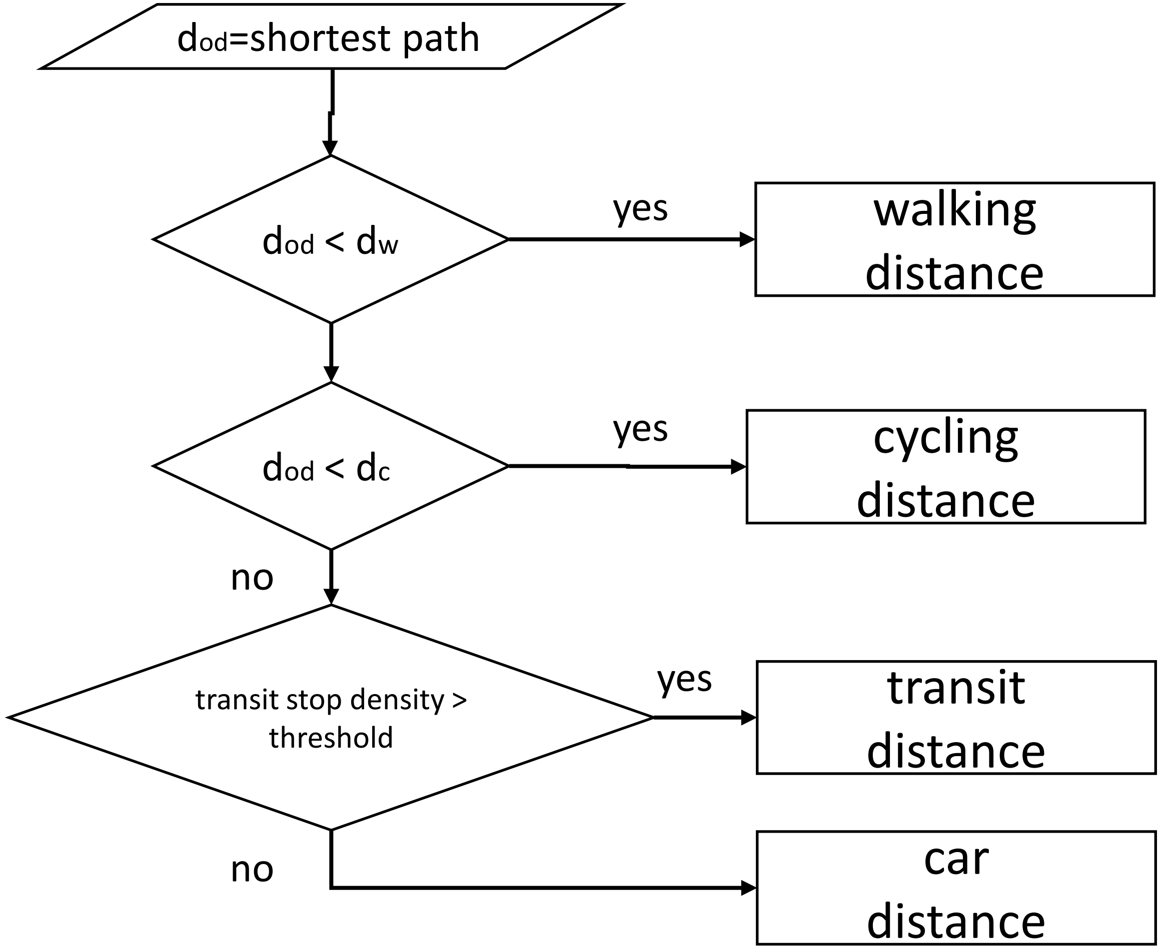

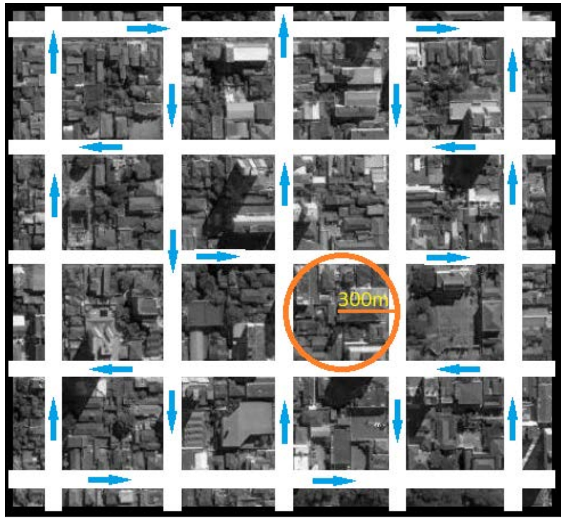

TRANSIT DENSITY THRESHOLD		
BUS	6.67	Km/km^2
LRT	3.30	Km/km^2
METRO	2.50	Km/km^2

Choice	Distance	
WALKING	<500m	d_{od}
CYCLING	<1000m	d_{od}
BUS	<300+300m	Stop access/egress
LRT	<600+600m	Stop access/egress
METRO	<800+800m	Stop access/egress

Optimal demand flows assignment

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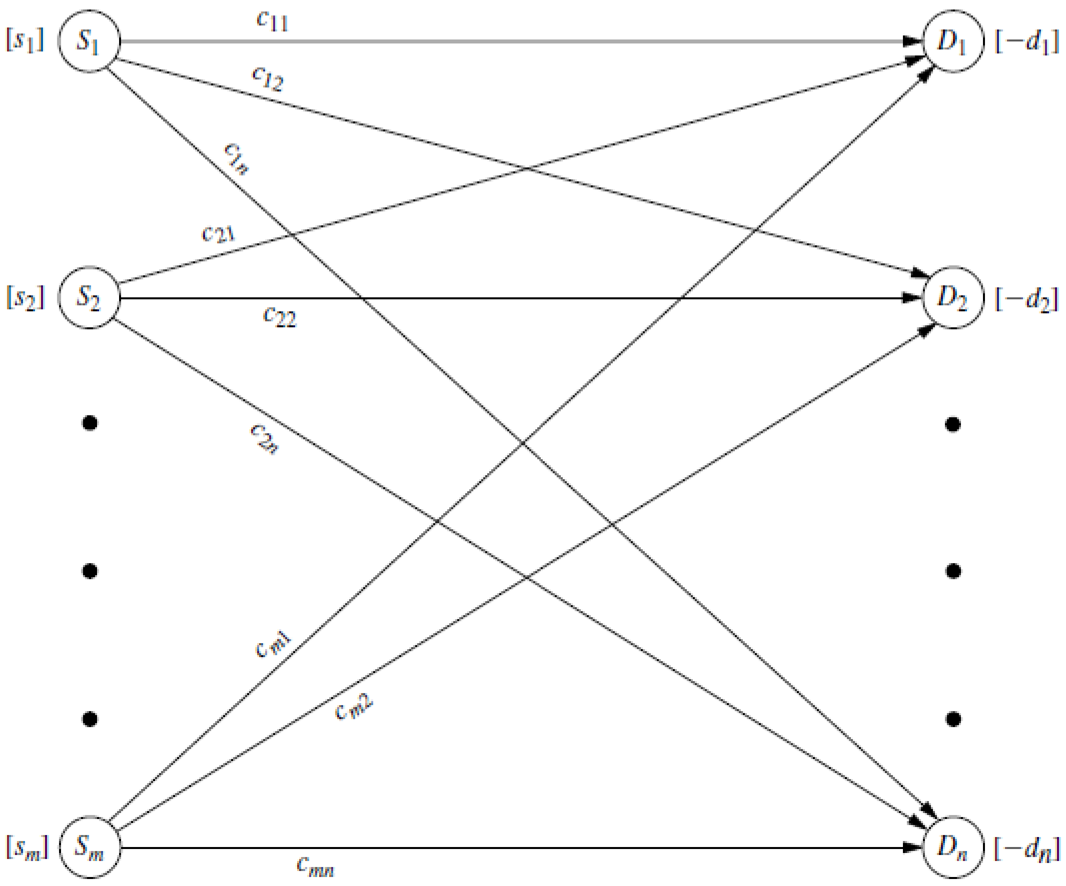
$$\min(Z) = \sum_{i=1}^{m} \sum_{j=1}^{n} c_{ij} x_{ij}$$

$$\sum_{j=1}^{n} x_{ij} = s_i$$

$$\sum_{i=1}^{m} x_{ij} = d_j$$

$$x_{ij} \geq 0$$

THE TRANSPORTATION PROBLEM



Hillier and Lieberman, 2001

Transport Energy Dependence

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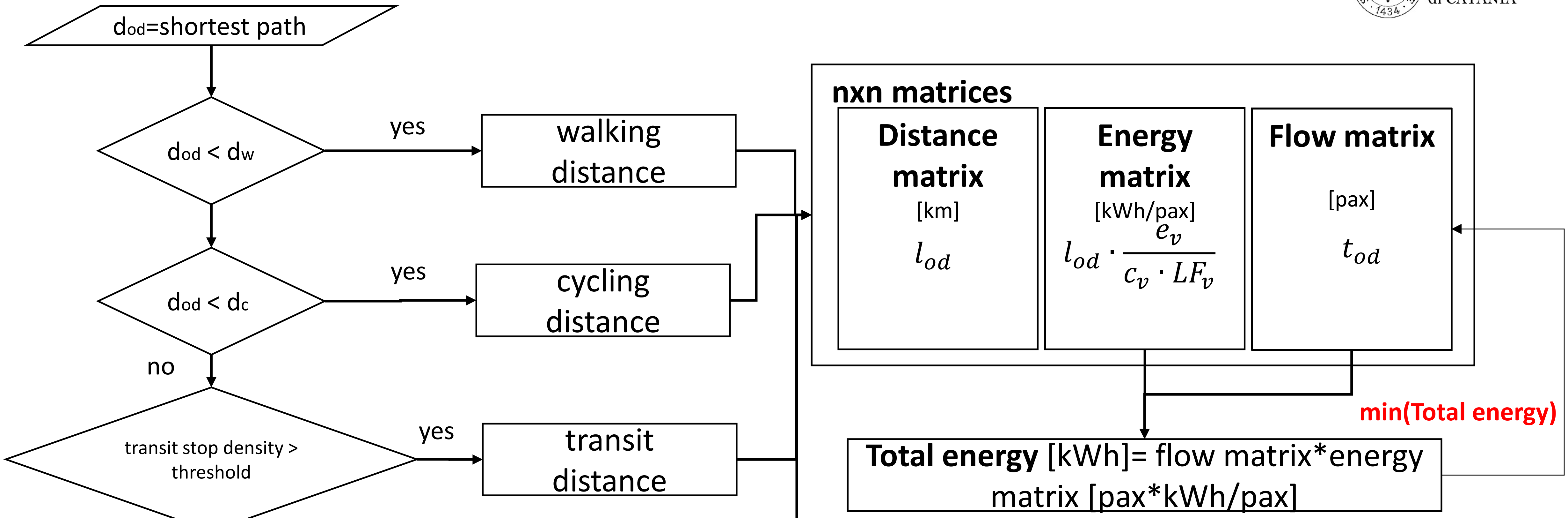
$$TED_s = \sum_o \sum_d \overbrace{\boxed{t_{od}}}^{X_{ij}^{opt}} \cdot \overbrace{\boxed{l_{od} \cdot \frac{e_v}{c_v \cdot LF_v}}}^{c_{ij}}$$

t_{od}	number of trips assigned from zone *o* to zone *d* to minimize *Z* (passengers)
l_{od}	shortest distance between zone *o* and zone *d* (km)
e_v	unit energy consumption of the chosen transport mode (kWh/km)
c_v	capacity of the vehicle (spaces)
LF_v	load factor (passengers/spaces)

Mode of transport	Unit energy consumption kWh/pax-km
Private Car	0.71-0.57
Regular Bus Transit	0.325
Bus Rapid Transit	0.192
Metro Transit	0.133

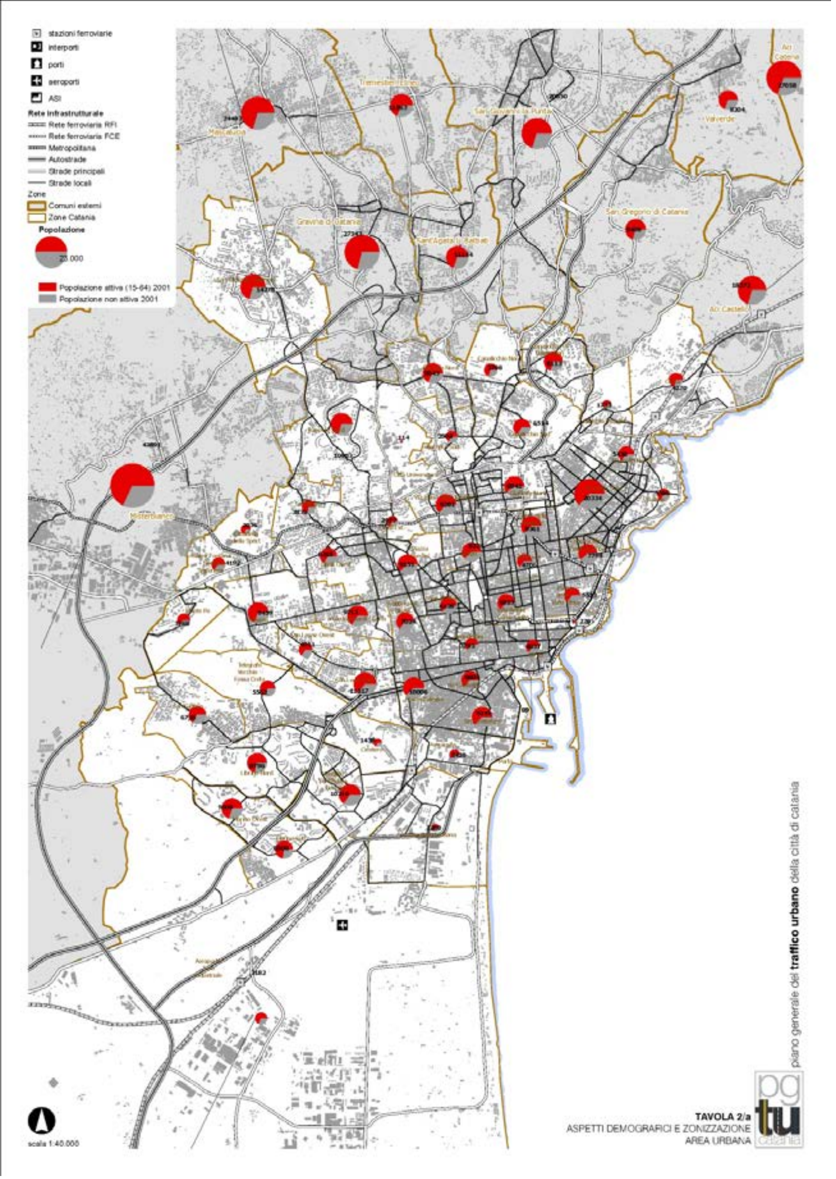
Kenworthy (2003)

Optimal demand flows assignment (n zones)

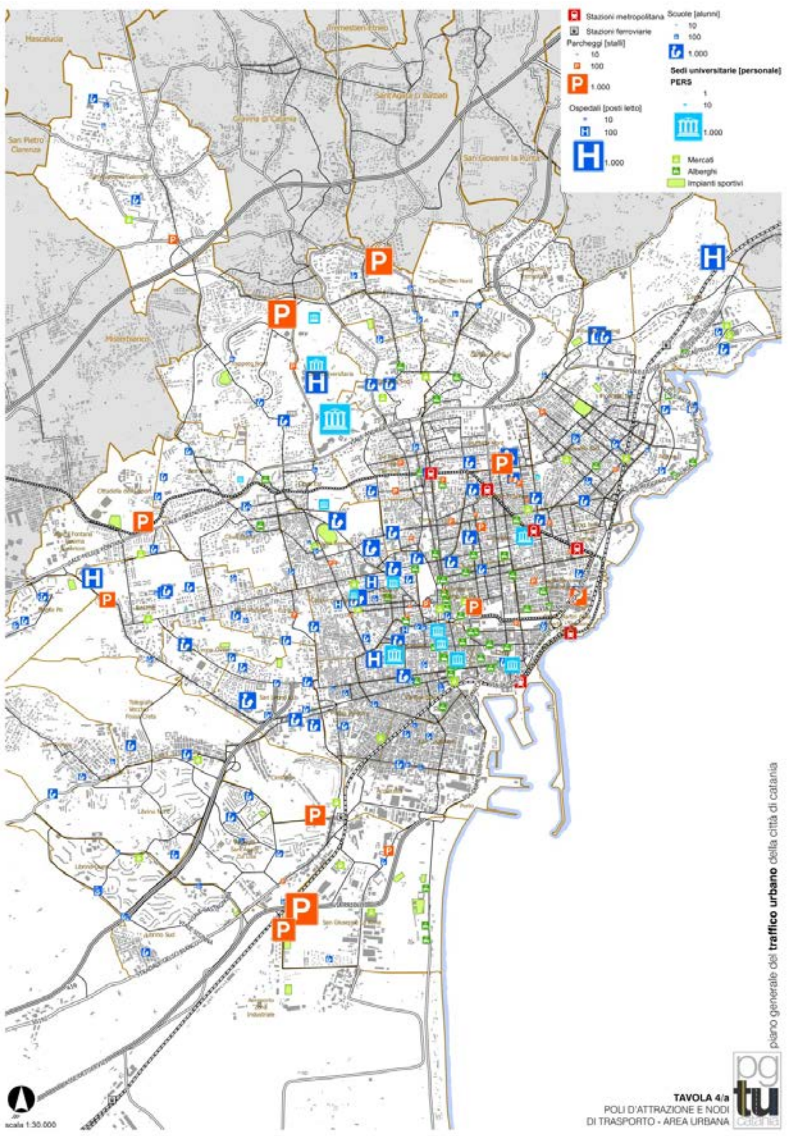


$$TED_s = \sum_o \sum_d t_{od} \cdot l_{od} \cdot \frac{e_v}{c_v \cdot LF_v}$$

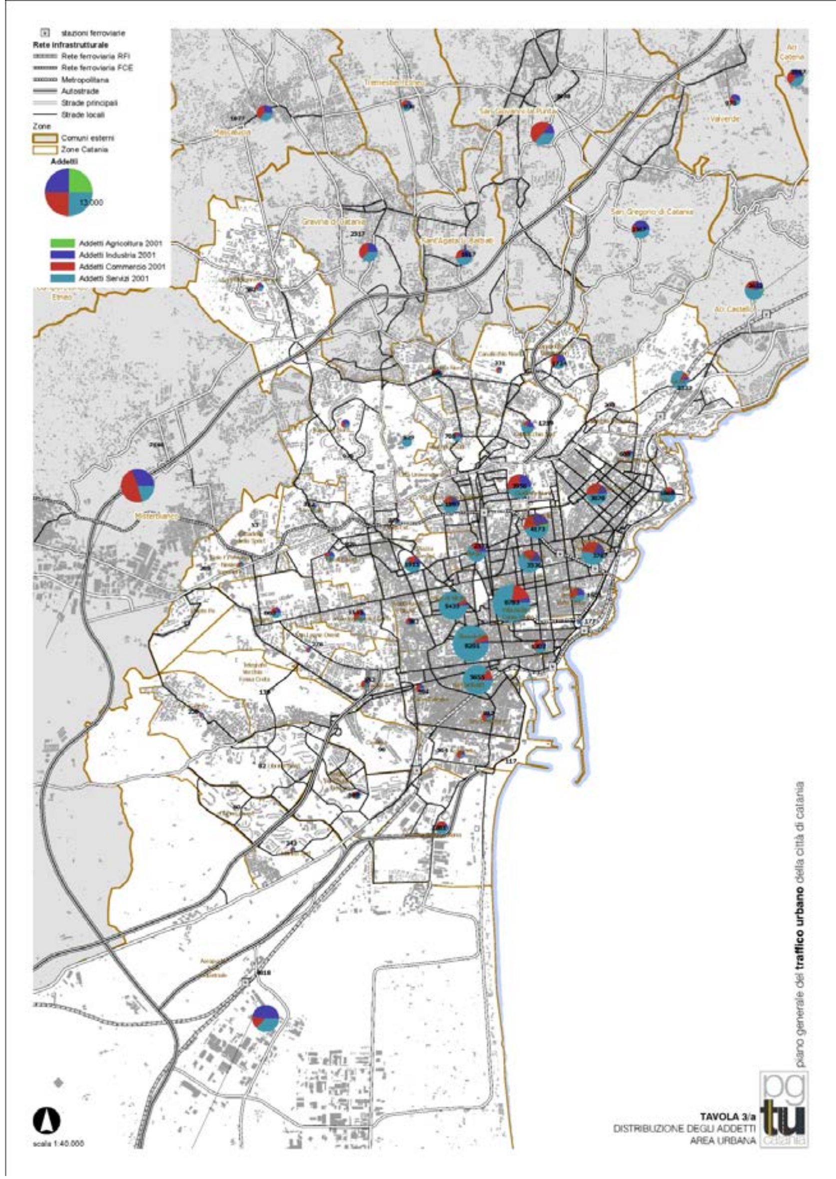
Case Study - Catania



population

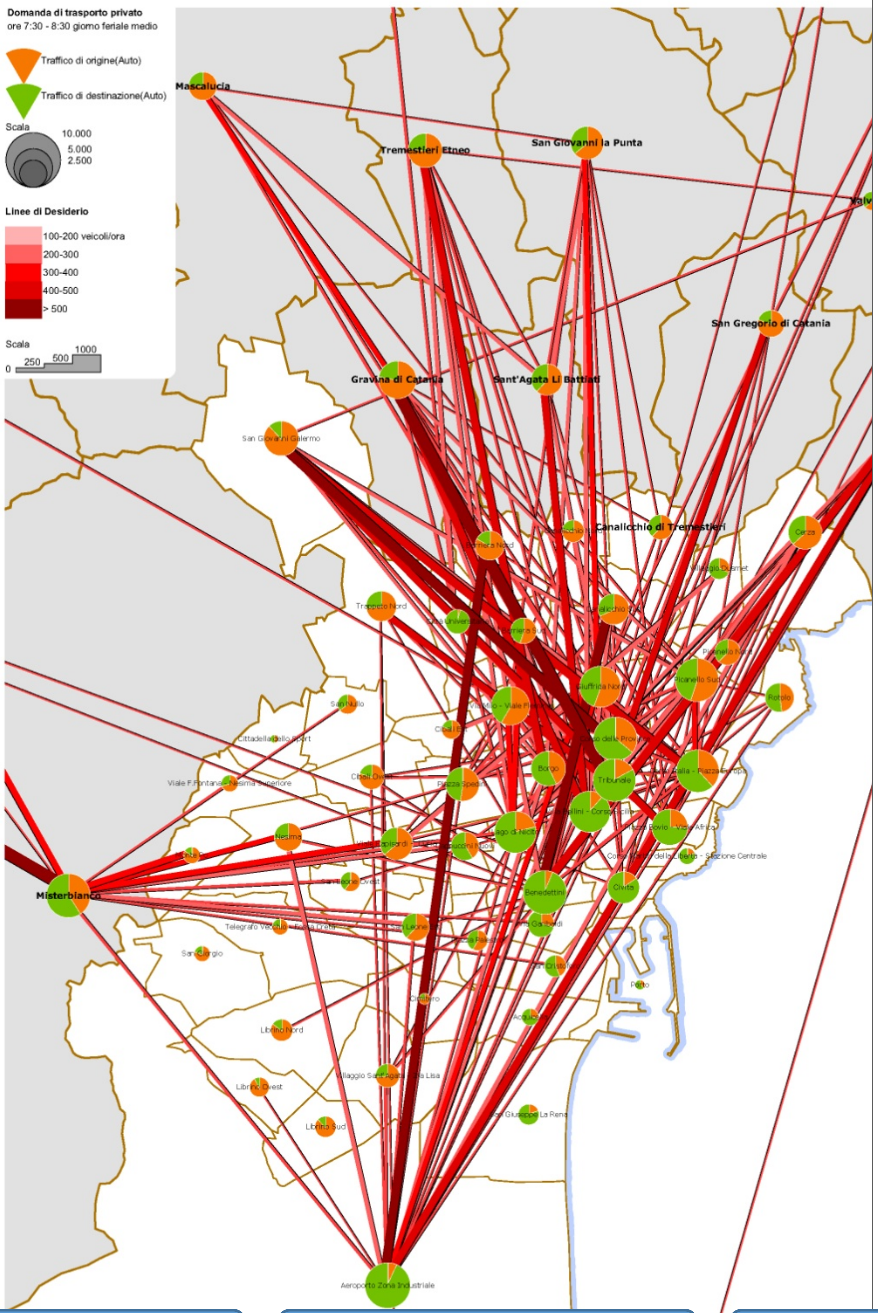


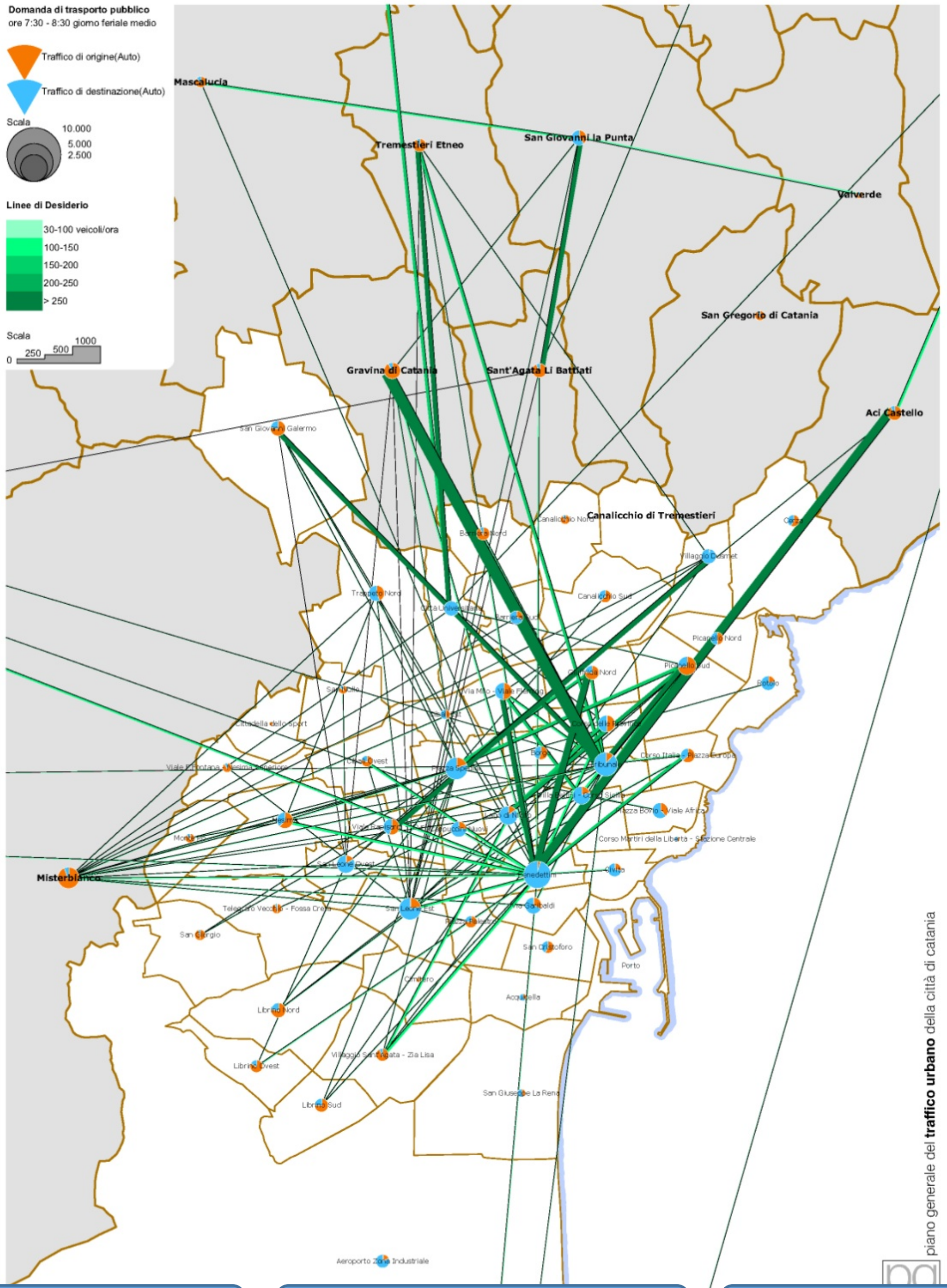
public services



jobs

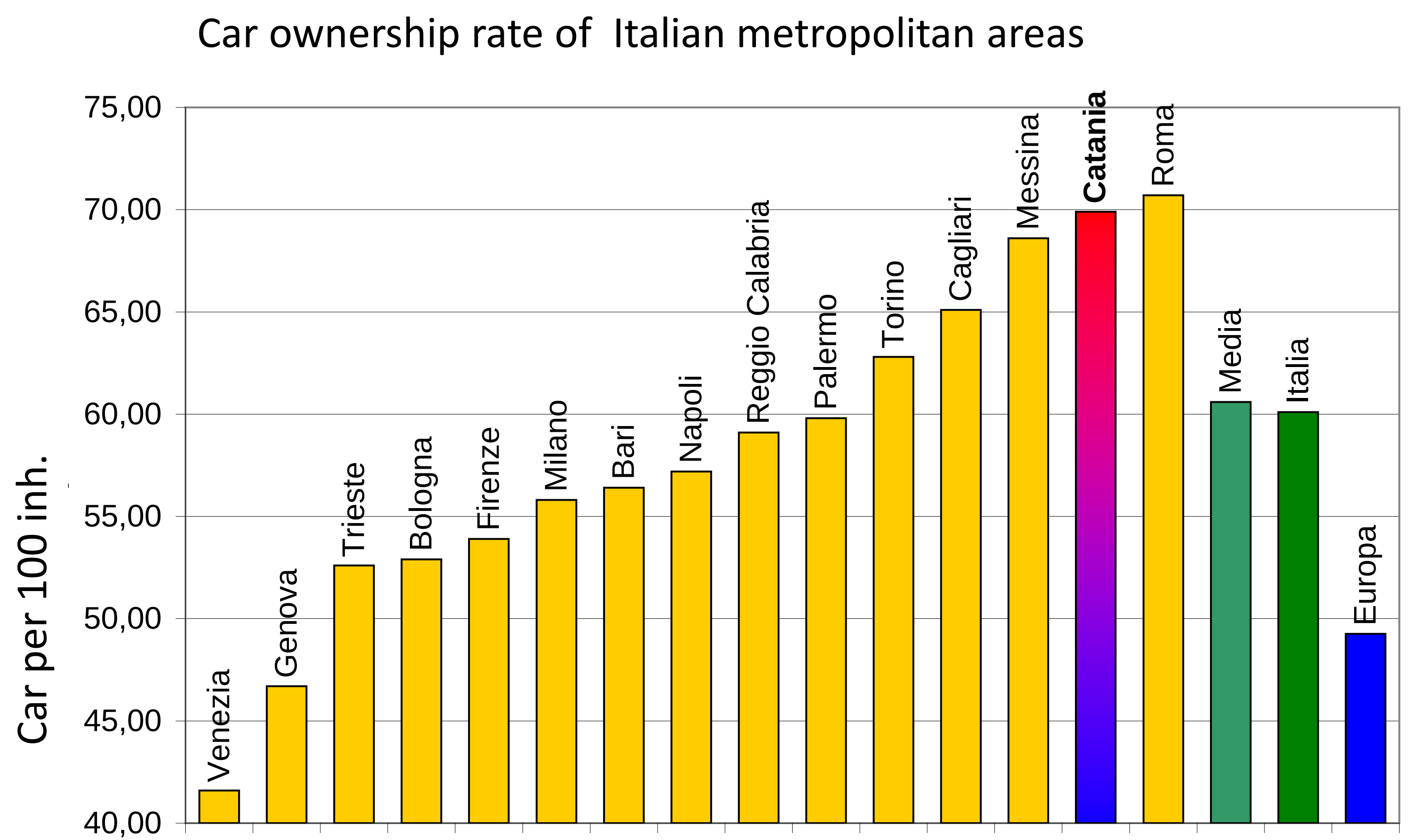
Private transport demand



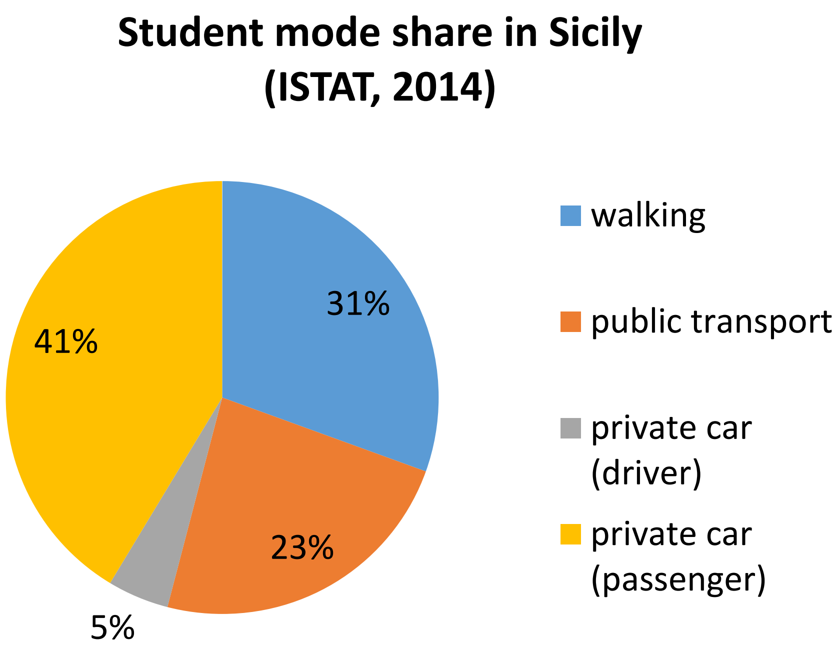


Public transport demand

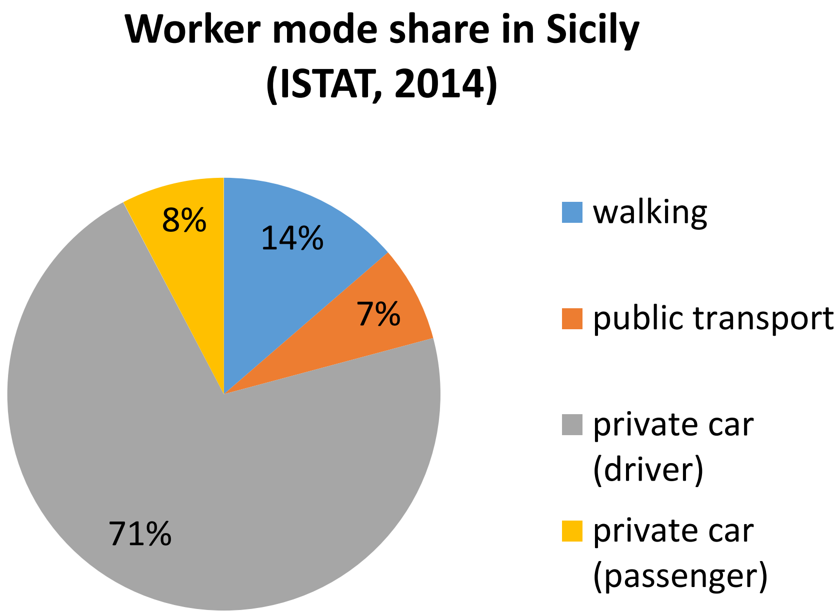
Car ownership rate (cars per 100 inh.)



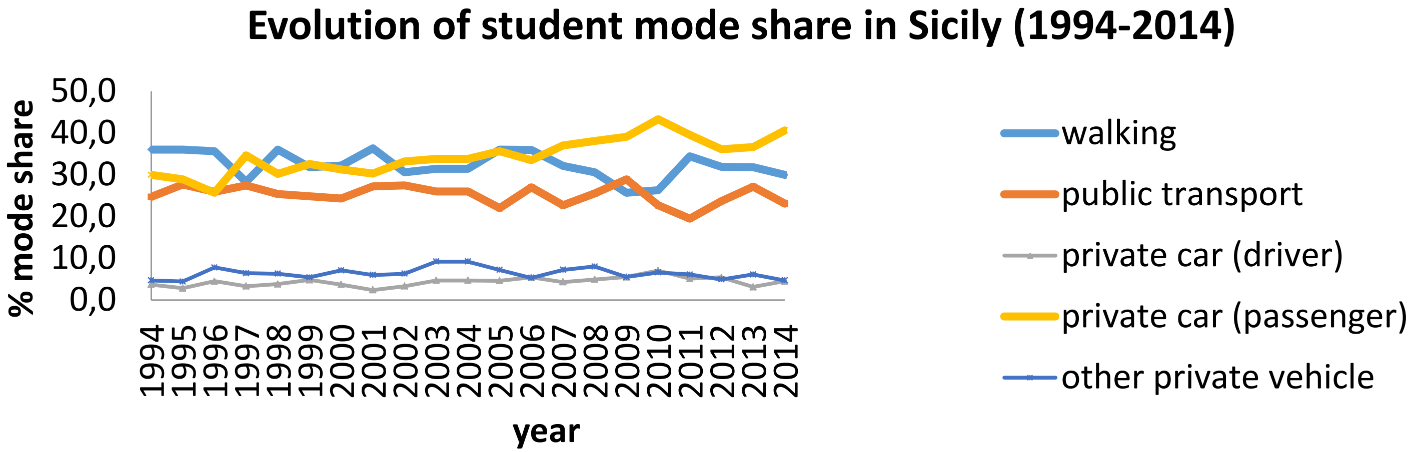
Mode share



Student mode share in Sicily
(ISTAT, 2014)
31%
23%
5%
41%
walking
public transport
private car (driver)
private car (passenger)



Worker mode share in Sicily
(ISTAT, 2014)
14%
7%
71%
8%
walking
public transport
private car (driver)
private car (passenger)

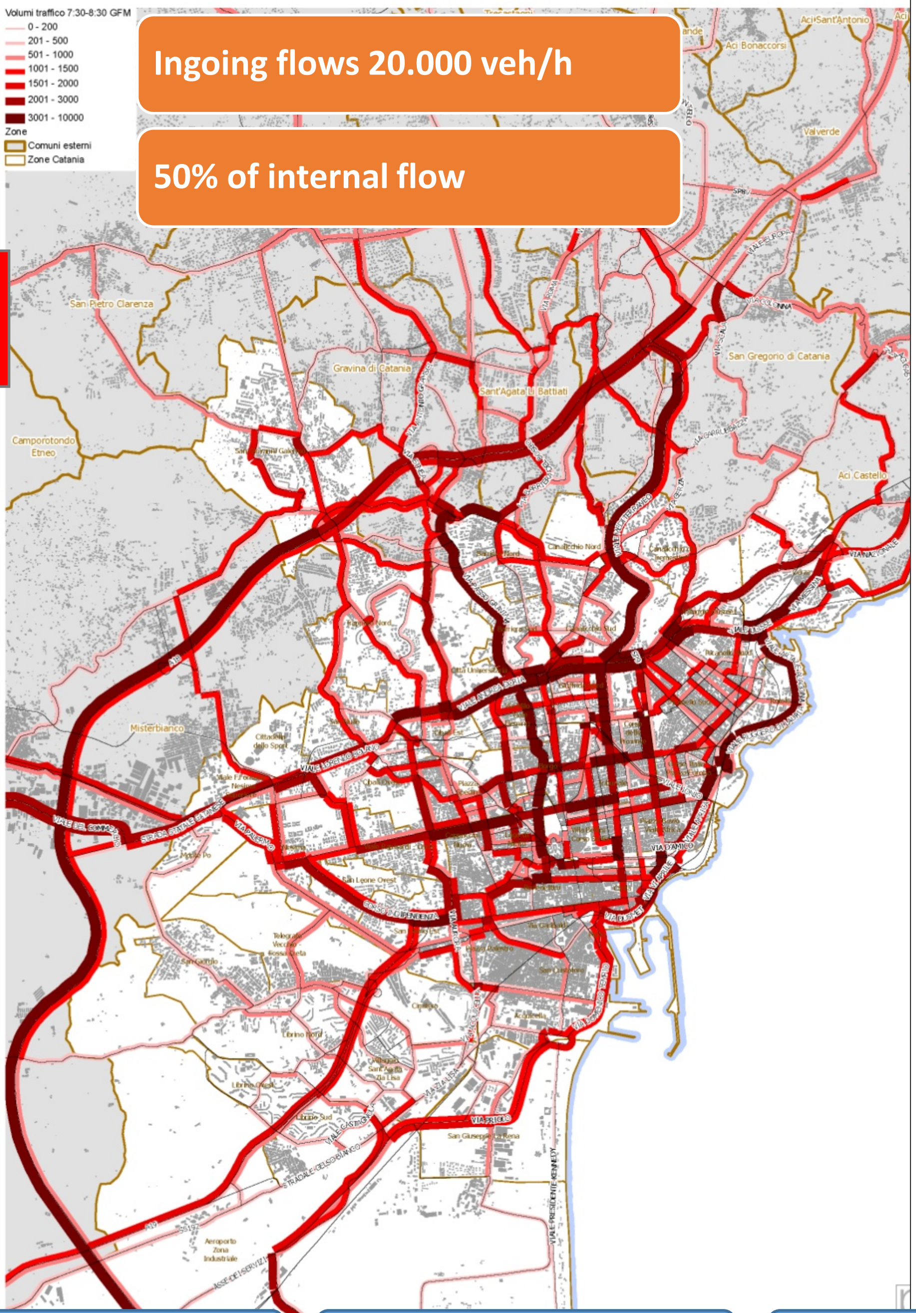


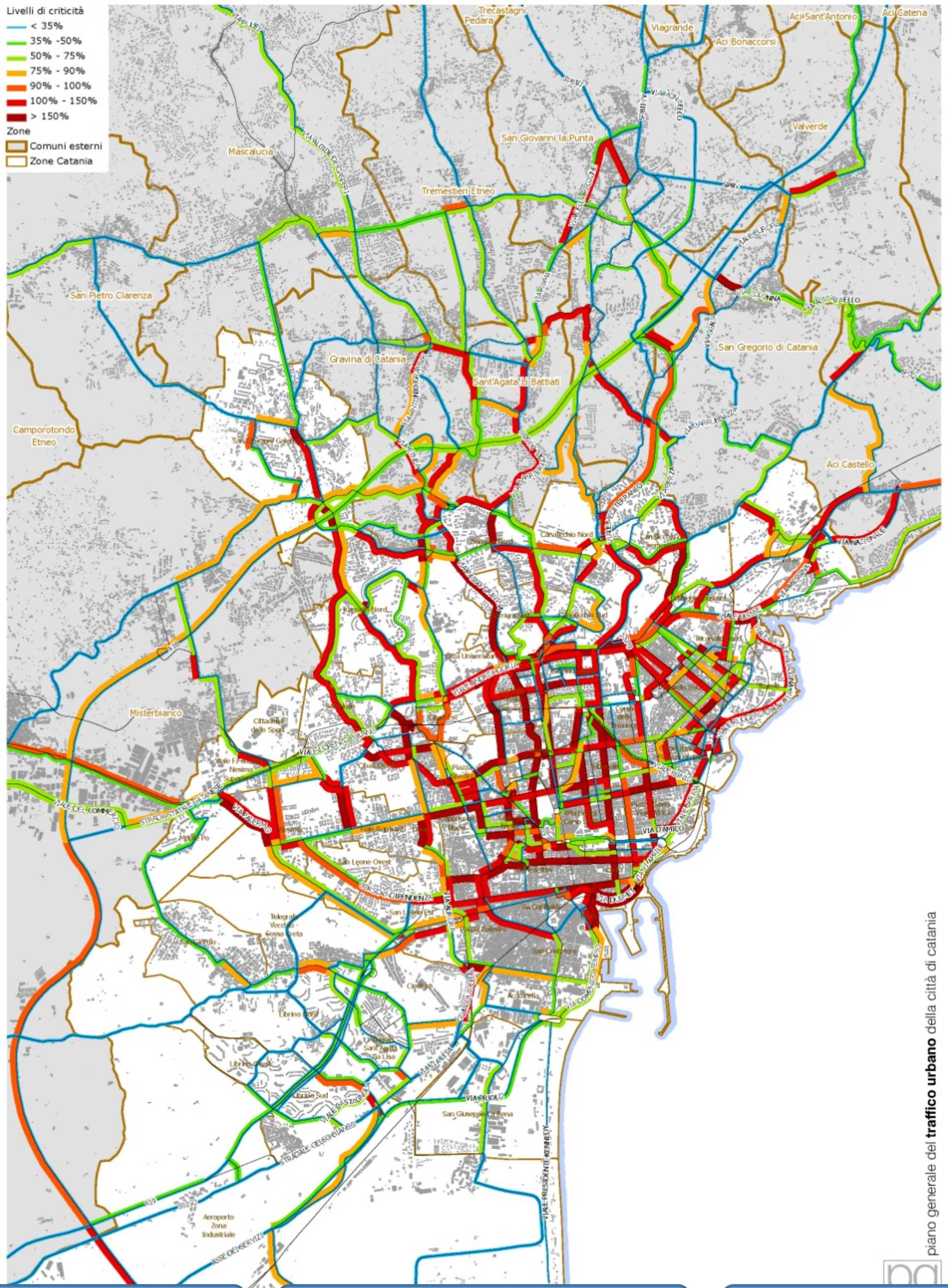
Evolution of student mode share in Sicily (1994-2014)
% mode share
50,0
40,0
30,0
20,0
10,0
0,0
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
year
walking
public transport
private car (driver)
private car (passenger)
other private vehicle

Peak hour traffic flow

Ingoing flows 20.000 veh/h

50% of internal flow

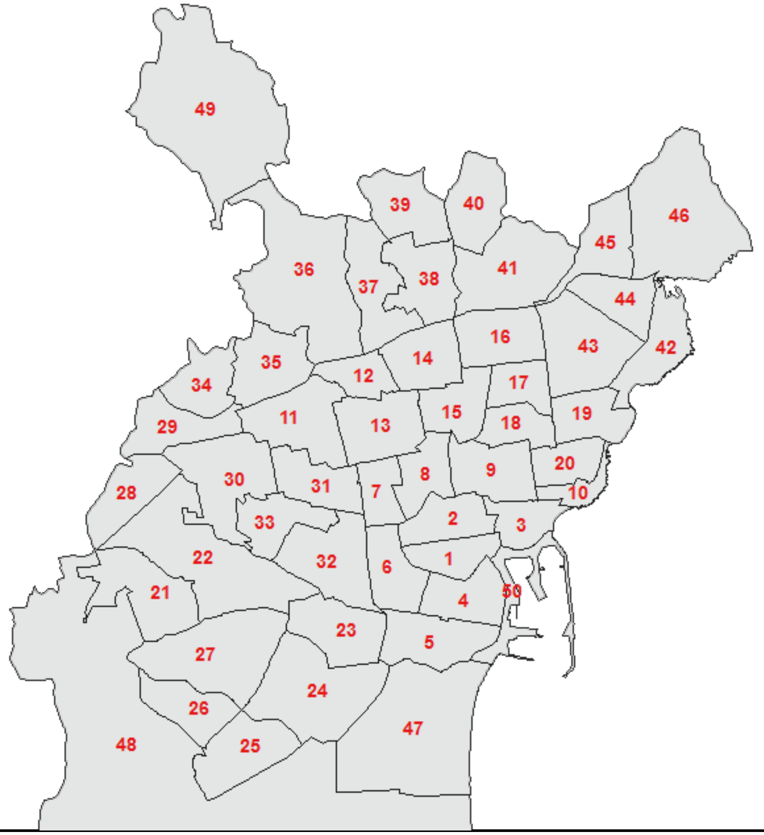




Road capacity saturation

Catania Land use Model

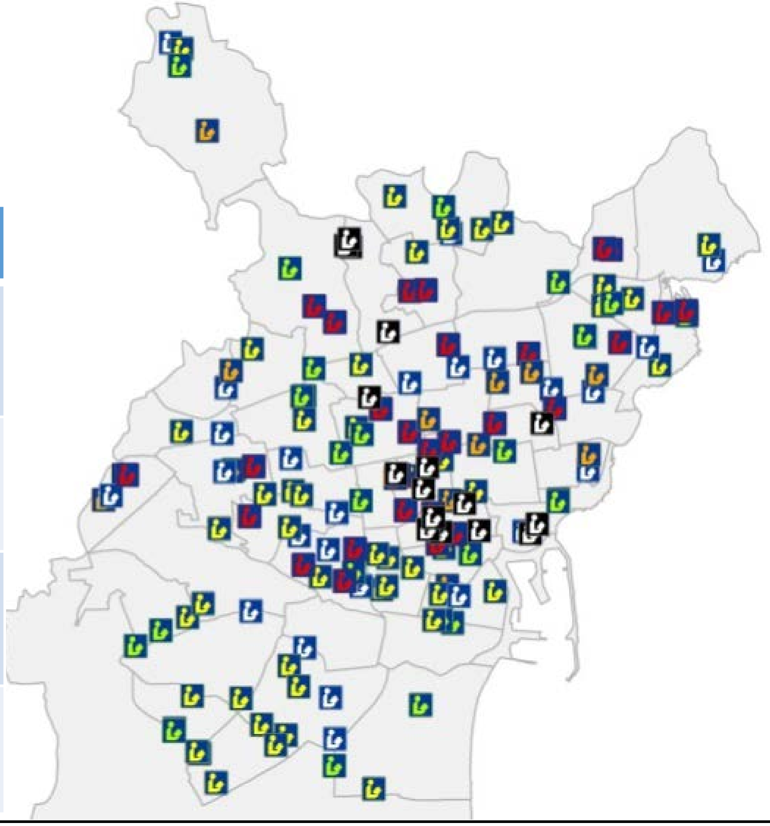
Zoning



Schools (blue) and university sites (black)

- kindergarten
- primary school
- lower secondary school
- upper secondary school

Student population	
Residents aged 3-18	82,000
University students	44,000
N of school sites	148
University sites	16



Catania Transport Model

- **Transport demand**:
  - Only students’ flows (5 trips/week)
- **Transport supply**:

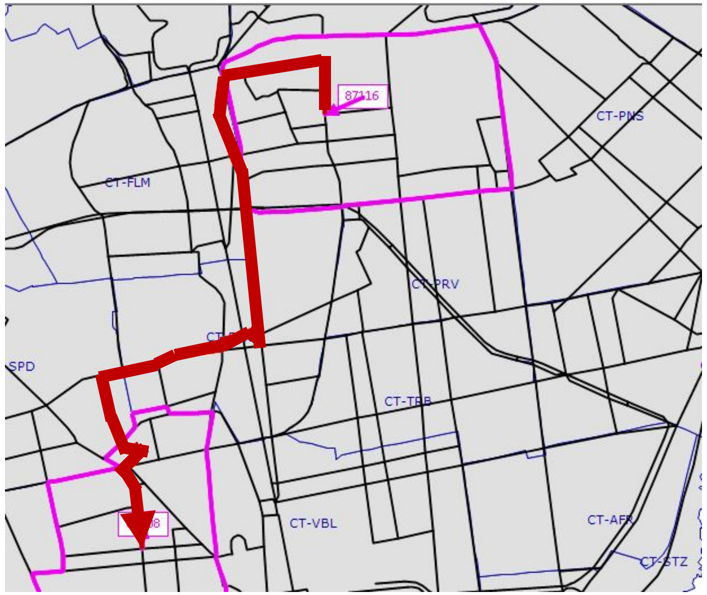
- road network
  - 516 nodes
  - 1122 links;
- transit network
  - 49 bus lines
  - 4 BRT lines
  - 1 metro line.

- **PTV VISUM** software package:

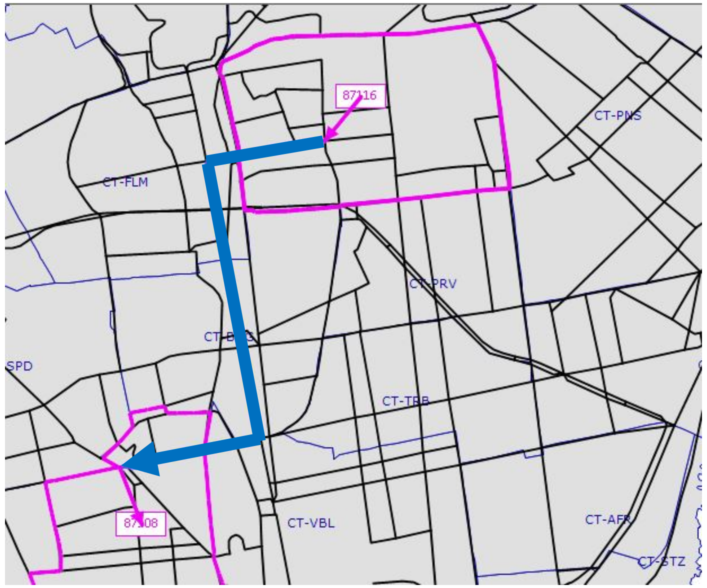
✓**shortest paths** between each OD by each mode of transport

✓**transit intermodality included**

Shortest path by car



Shortest path by transit



Transport mode choice model

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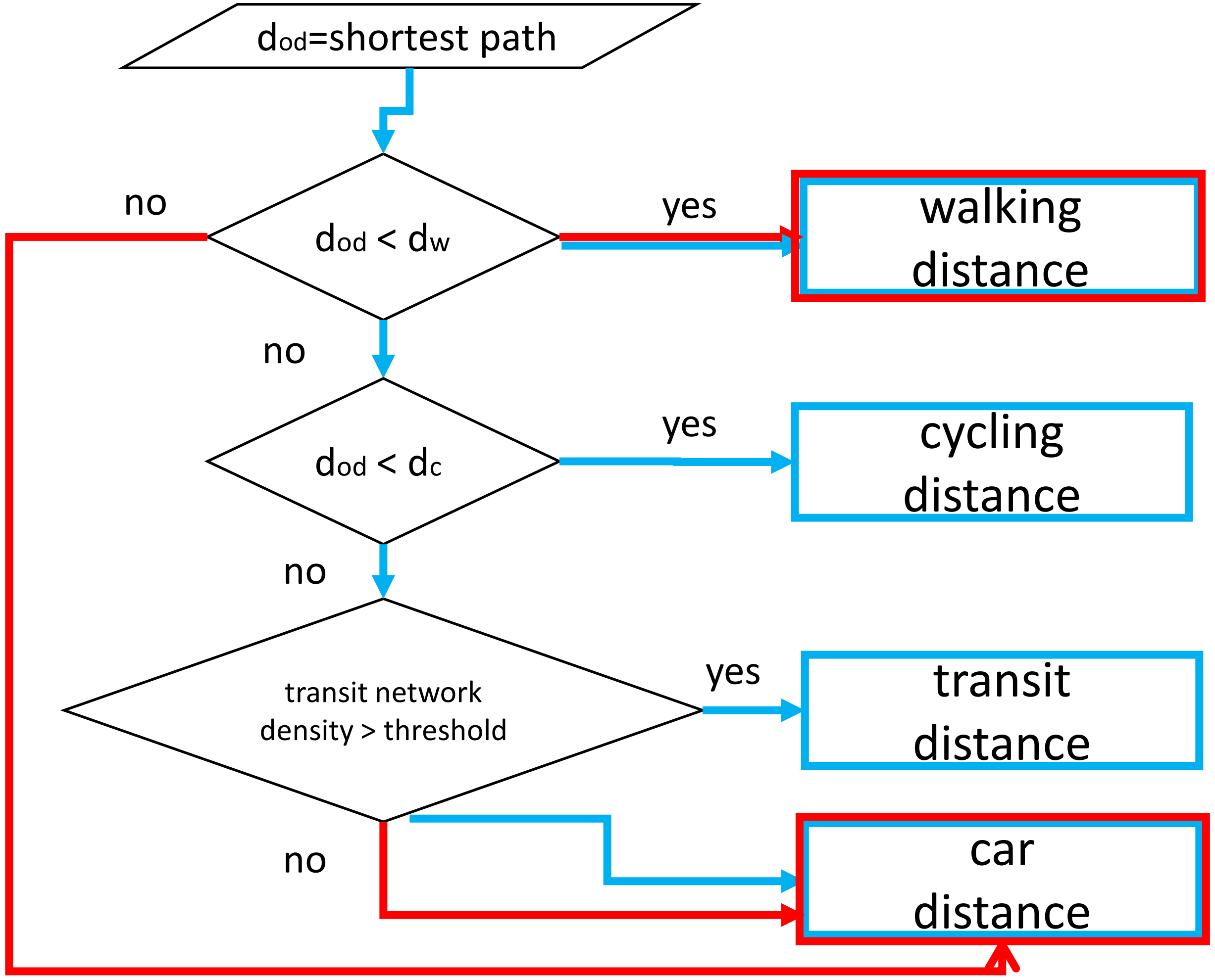


Kindergarten and primary school

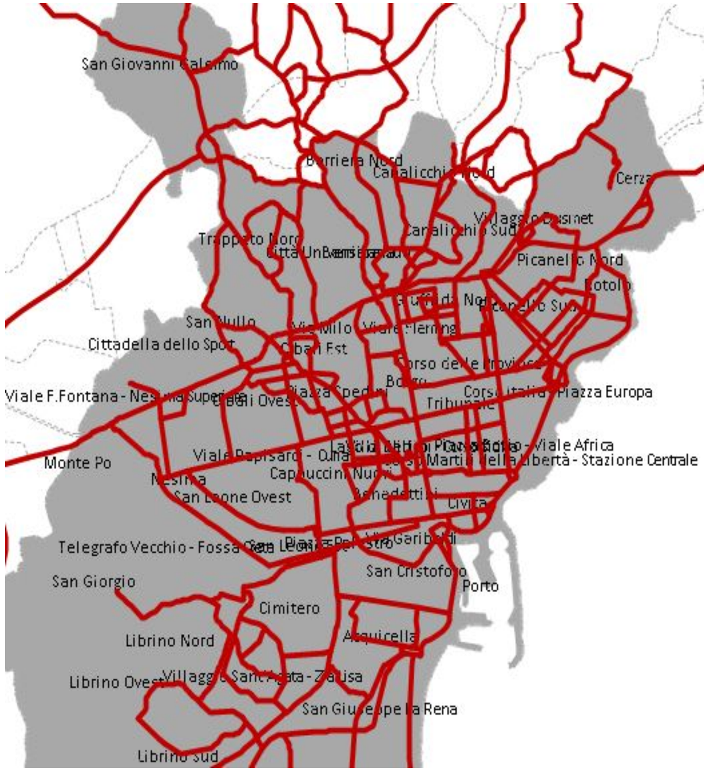
Lower and upper secondary school, university

Choice	Distance	
Walking	<500m	d_{od}
Cycling	<1000m	d_{od}
Regular Bus Transit	<300+300m	Stop access/egress
Bus Rapid Transit	<600+600m	Stop access/egress
Metro Transit	<800+800m	Stop access/egress

Transit network	Maximum walking distance (m)	Transit density threshold (km/km^2)
Regular Bus Transit	300	6.67
Bus Rapid Transit	600	3.30
Metro Transit	800	2.50

Scenario 0 - Reference scenario

Transit network

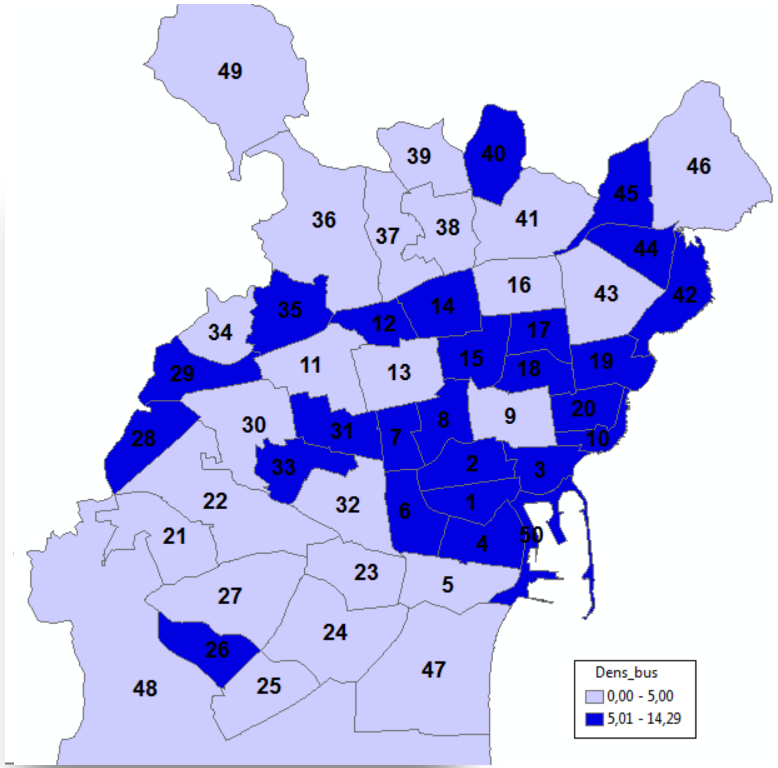


Road network

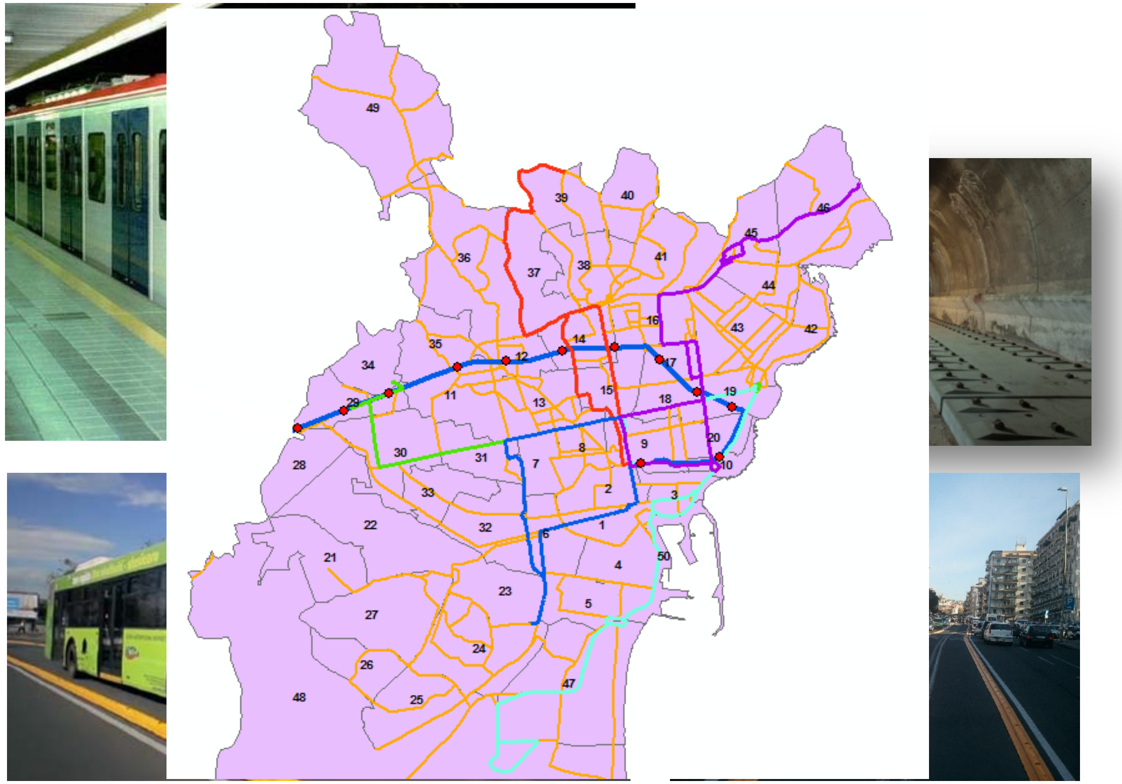
Research Question | Methodology | Case Study | Results | Conclusions

Scenarios 1,2 - Transport Policies

Sc.1: improving walking accessibility to PT

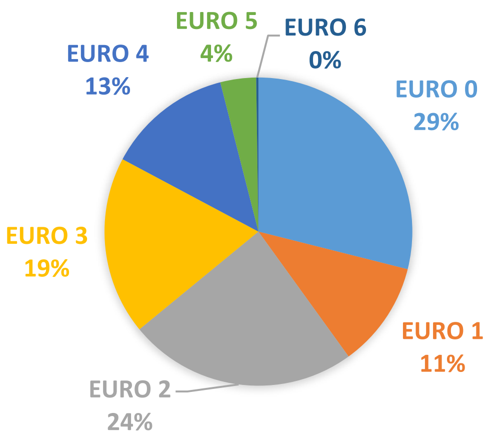


Sc.2: enhancing PT (BRT and Metro)



Scenarios 3 - Energy Policies

SC 0

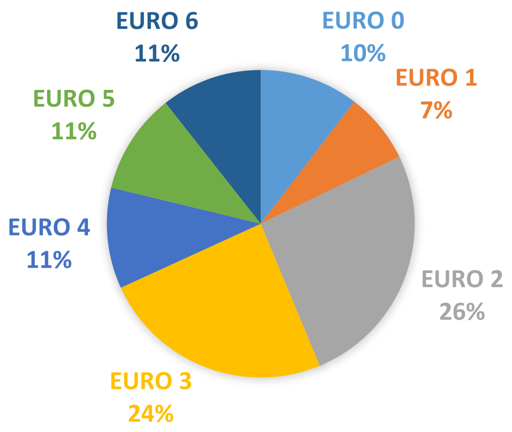


	Composizione del parco autovetture per standard emissivo (valori %)						
	Euro 4 e 5	Euro 3	Euro 2	Euro 1	Euro 0	Altro	Totale
Bari	23,6	25,8	26,2	9,1	15,3	0,0	100
Bologna	31,8	24,4	25,9	7,4	10,4	0,0	100
Cagliari	25,7	24,8	26,2	8,1	15,1	0,1	100
Catania	17,2	18,7	24,0	11,1	28,9	0,1	100
Firenze	31,6	26,7	25,6	6,6	9,5	0,0	100
Genova	28,4	25,3	27,9	8,4	10,0	0,0	100
Messina	21,0	22,6	26,6	9,9	19,8	0,1	100
Milano	29,4	24,6	25,1	7,8	13,2	0,0	100
Napoli	14,6	16,2	24,8	11,1	33,1	0,2	100
Palermo	22,1	22,1	26,3	9,8	19,6	0,1	100
Reggio Calabria	21,3	24,5	26,3	9,6	18,3	0,1	100
Roma	32,5	23,1	21,0	10,2	13,1	0,1	100
Torino	31,2	24,0	25,7	6,6	12,4	0,1	100
Trieste	25,8	22,1	29,4	9,7	13,0	0,0	100
Venezia	27,2	23,7	28,7	9,1	11,2	0,0	100
Media 15 città	27,6	22,9	24,3	9,2	15,9	0,1	100
Media Italia	23,0	24,1	27,3	9,6	16,0	0,1	100

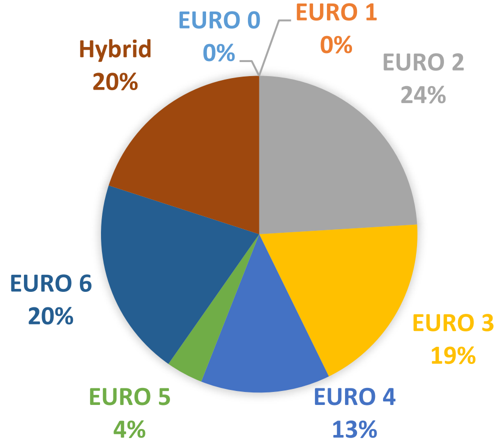
Nota: *"Altro" comprende le autovetture per le quali lo standard emissivo è "non identificato" o "non contemplato"*

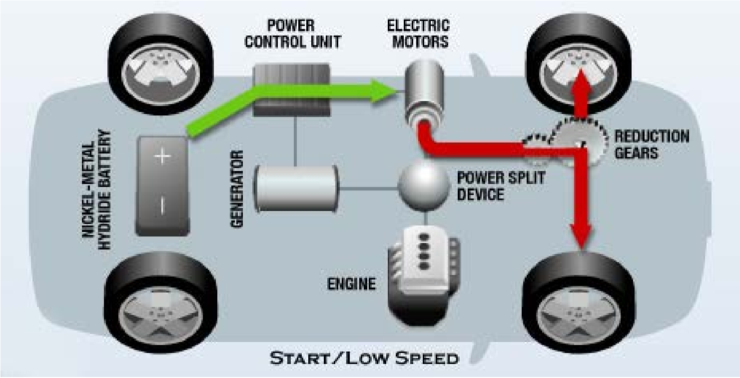
Fonte: elaborazione Cittalia su dati Istat e Aci, 2009

SC 3A (BOLOGNA)

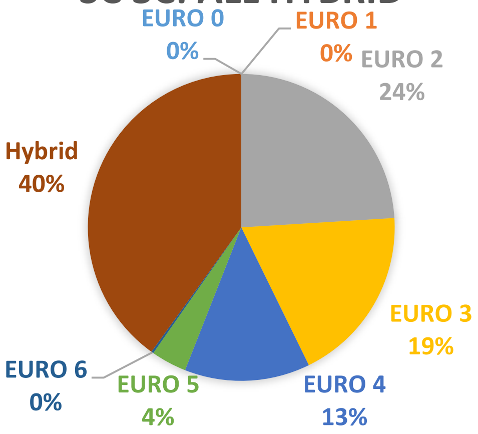


SC 3B: 50% HYBRID 50% EURO 6

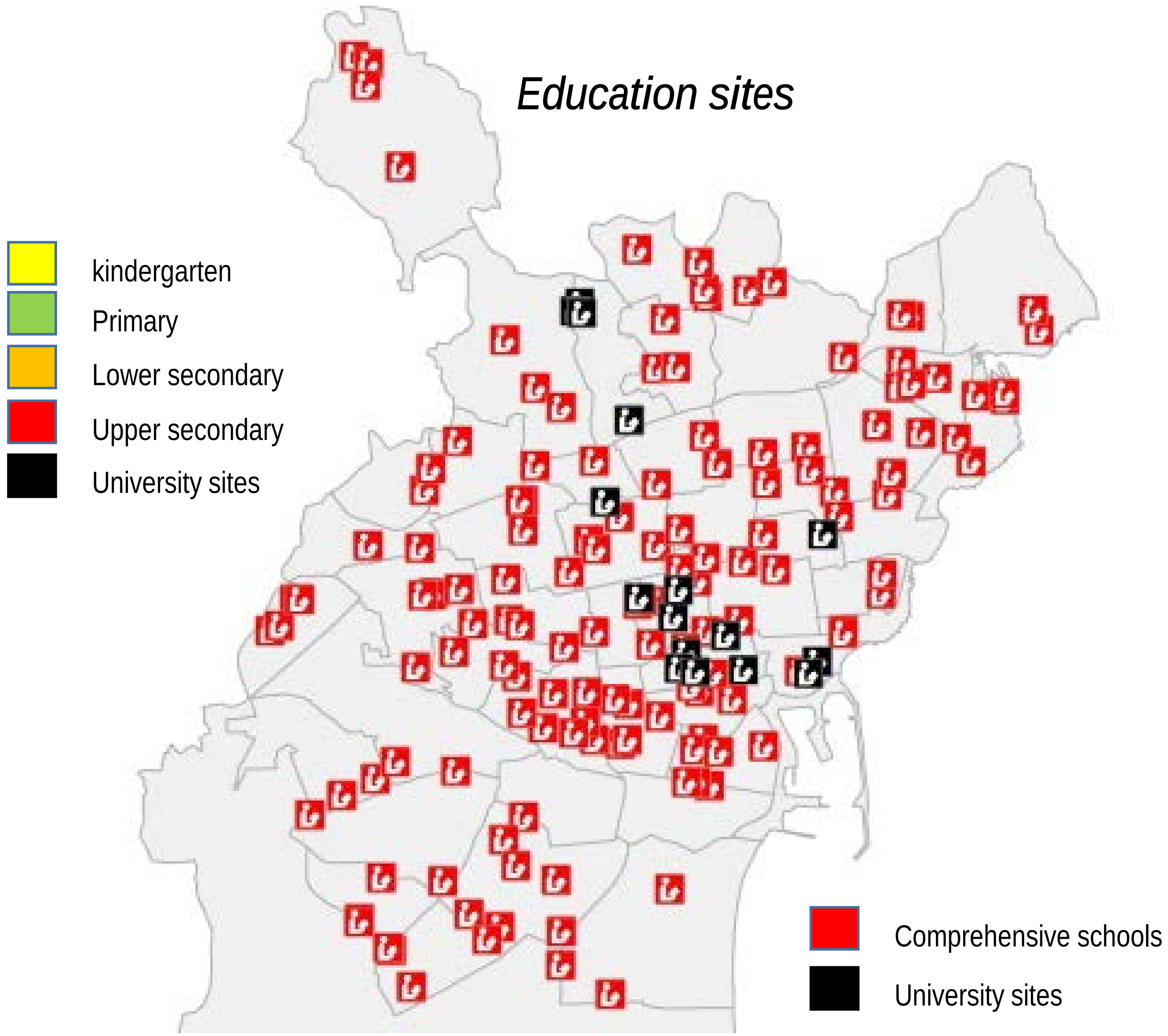




SC 3C: ALL HYBRID

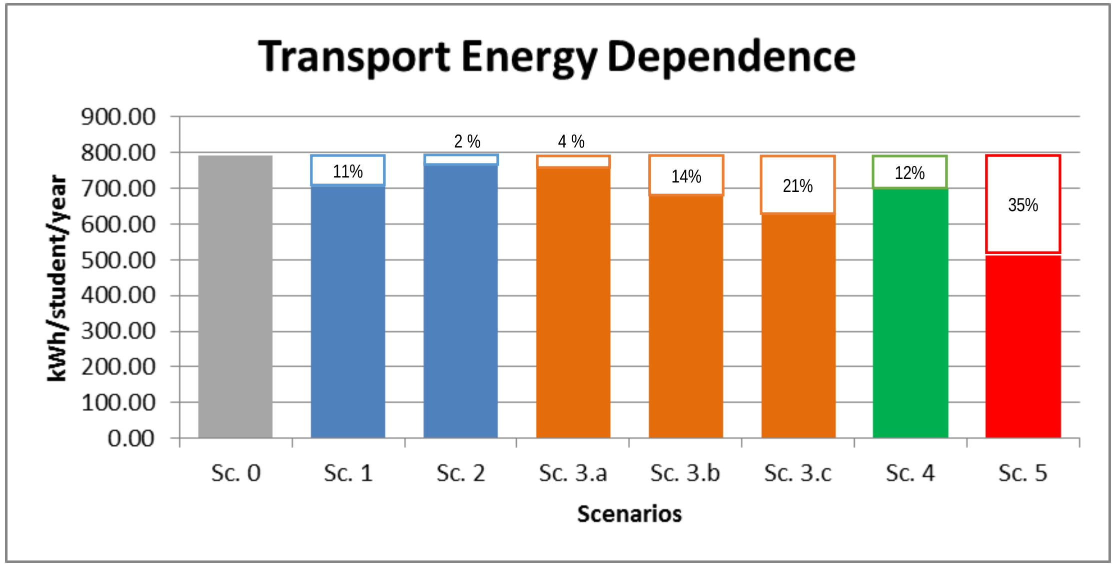


Scenarios 4 – Land use Policies

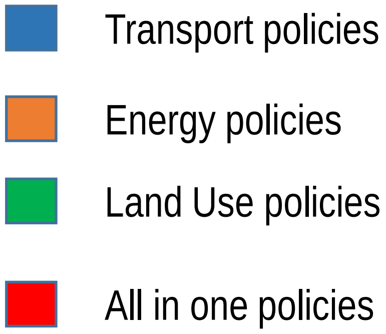


Scenario 5 – 1,2,3c,4 all in one

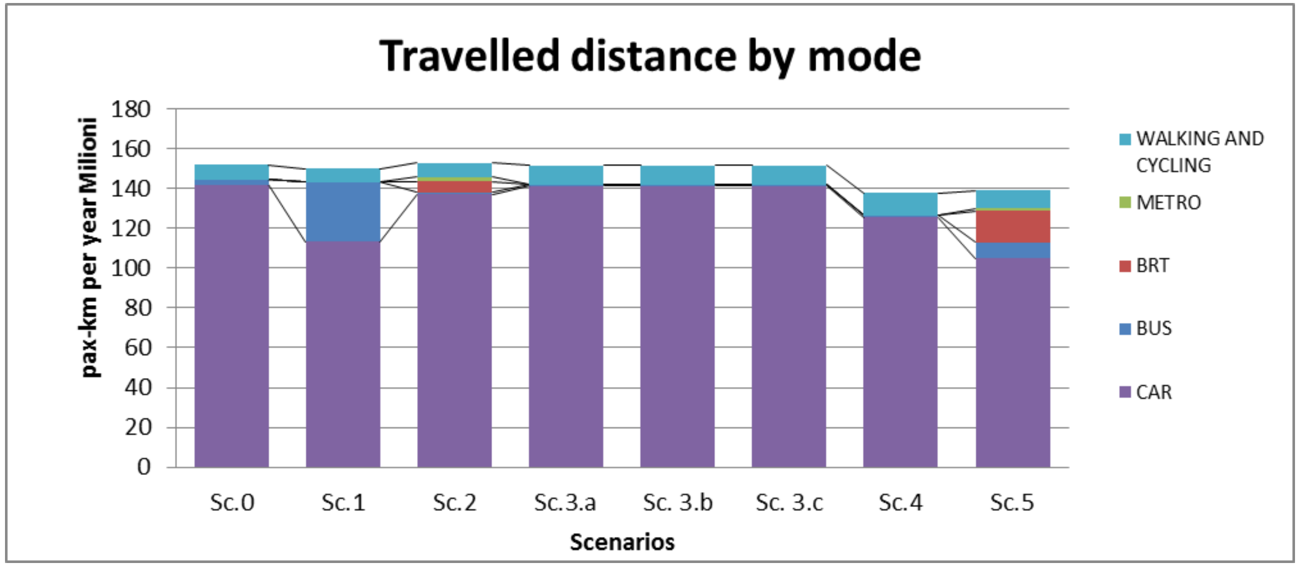
Results (1/3)



Transport Energy Dependence
900.00
800.00
700.00
600.00
500.00
400.00
300.00
200.00
100.00
0.00
kWh/student/year
11%
2 %
4 %
14%
21%
12%
35%
Sc. 0
Sc. 1
Sc. 2
Sc. 3.a
Sc. 3.b
Sc. 3.c
Sc. 4
Sc. 5
Scenarios

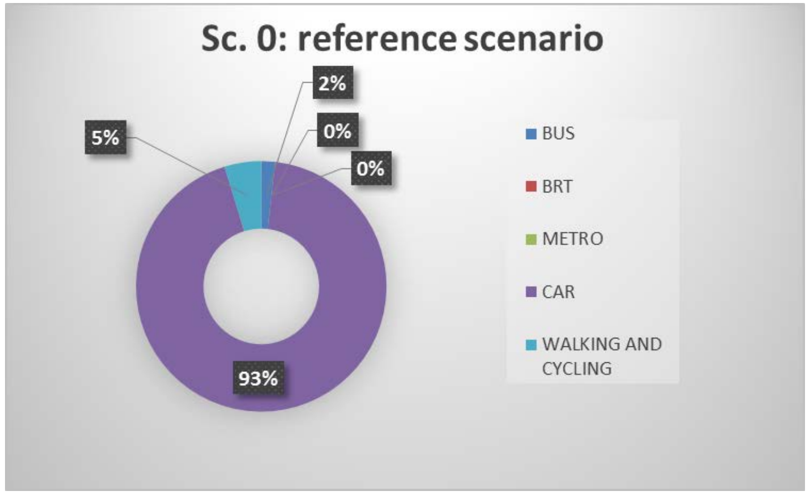


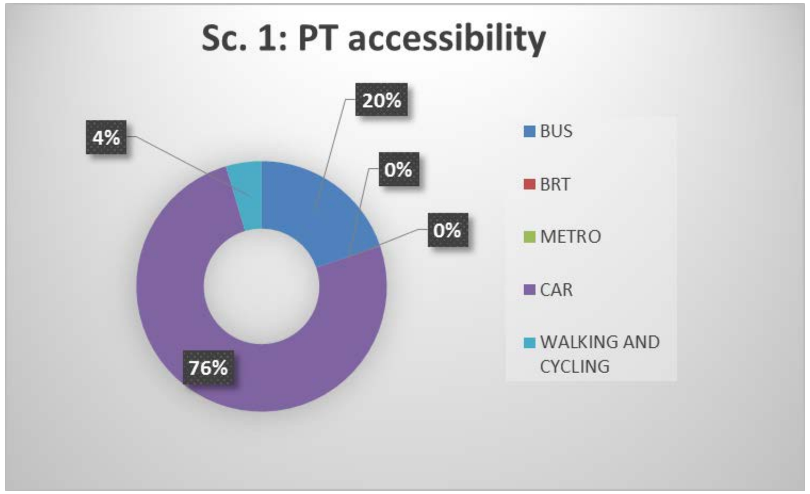
Transport policies
Energy policies
Land Use policies
All in one policies

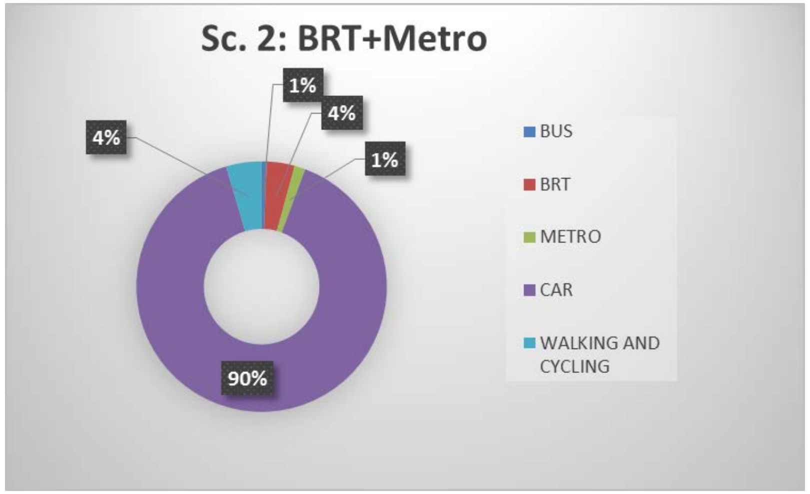


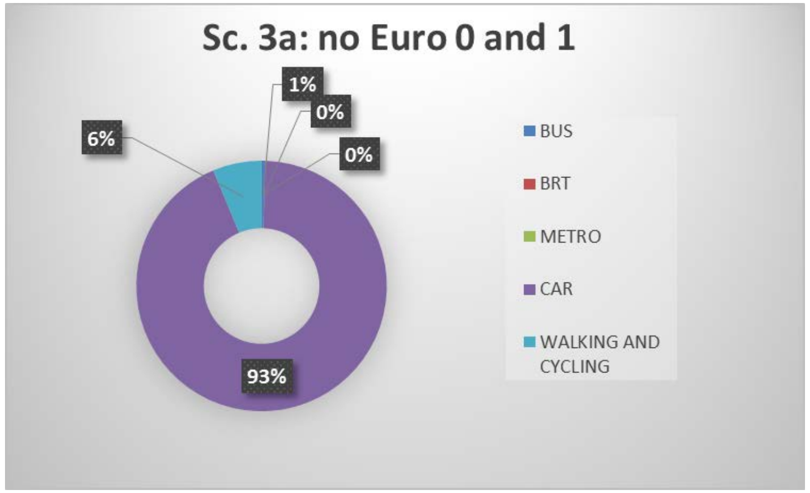
Travelled distance by mode
180
160
140
120
100
80
60
40
20
0
pax-km per year Milioni
WALKING AND CYCLING
METRO
BRT
BUS
CAR
Sc.0
Sc.1
Sc.2
Sc.3.a
Sc. 3.b
Sc. 3.c
Sc.4
Sc.5
Scenarios

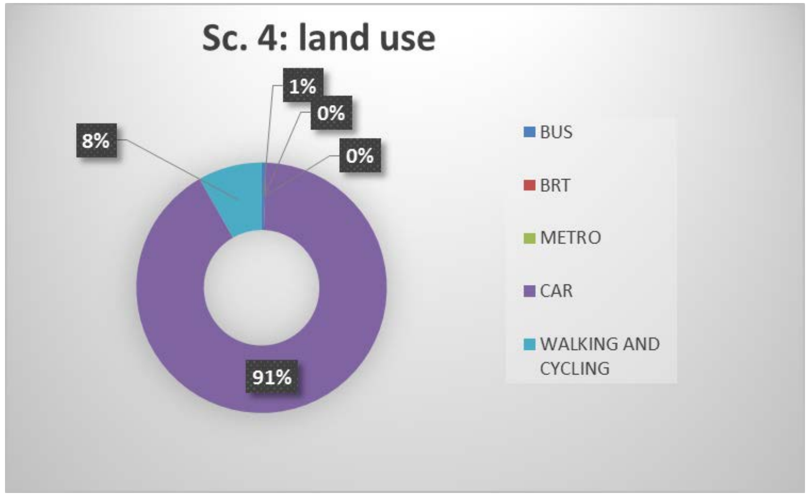
Results (2/3)

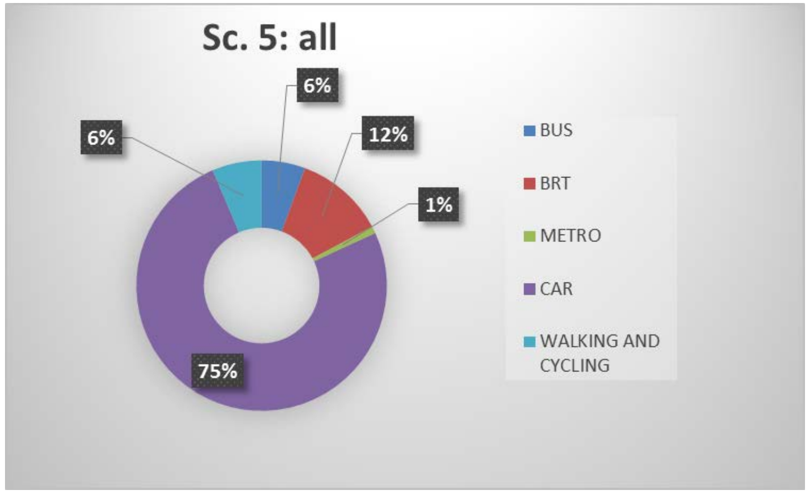

Sc. 0: reference scenario
2%
0%
0%
5%
93%
BUS
BRT
METRO
CAR
WALKING AND CYCLING


Sc. 1: PT accessibility
20%
0%
0%
4%
76%
BUS
BRT
METRO
CAR
WALKING AND CYCLING

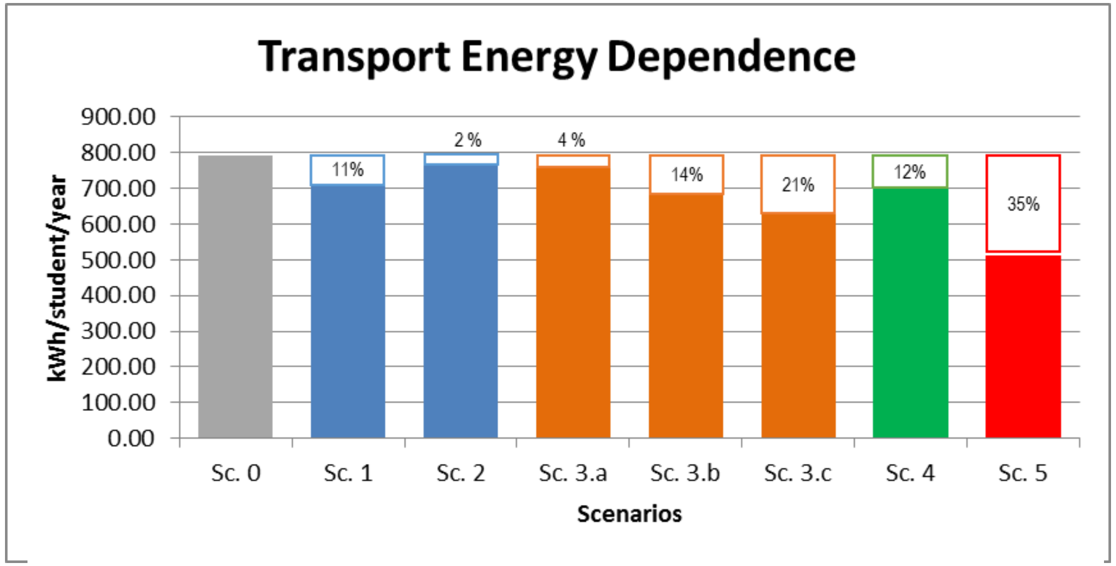

Sc. 2: BRT+Metro
1%
4%
1%
4%
90%
BUS
BRT
METRO
CAR
WALKING AND CYCLING


Sc. 3a: no Euro 0 and 1
1%
0%
0%
6%
93%
BUS
BRT
METRO
CAR
WALKING AND CYCLING


Sc. 4: land use
1%
0%
0%
8%
91%
BUS
BRT
METRO
CAR
WALKING AND CYCLING


Sc. 5: all
6%
12%
1%
6%
75%
BUS
BRT
METRO
CAR
WALKING AND CYCLING

Results (3/3)

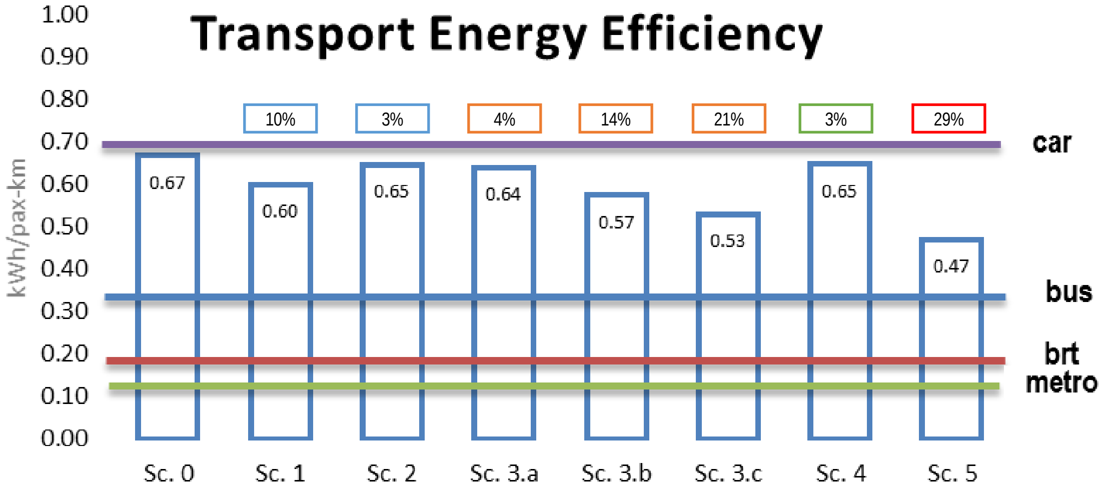


Transport policies

Energy policies

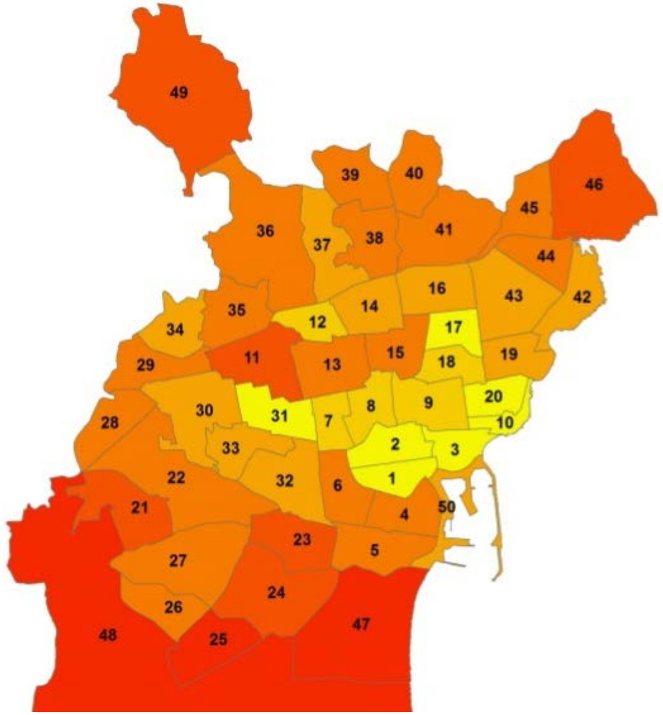
Land Use policies

All in one policies

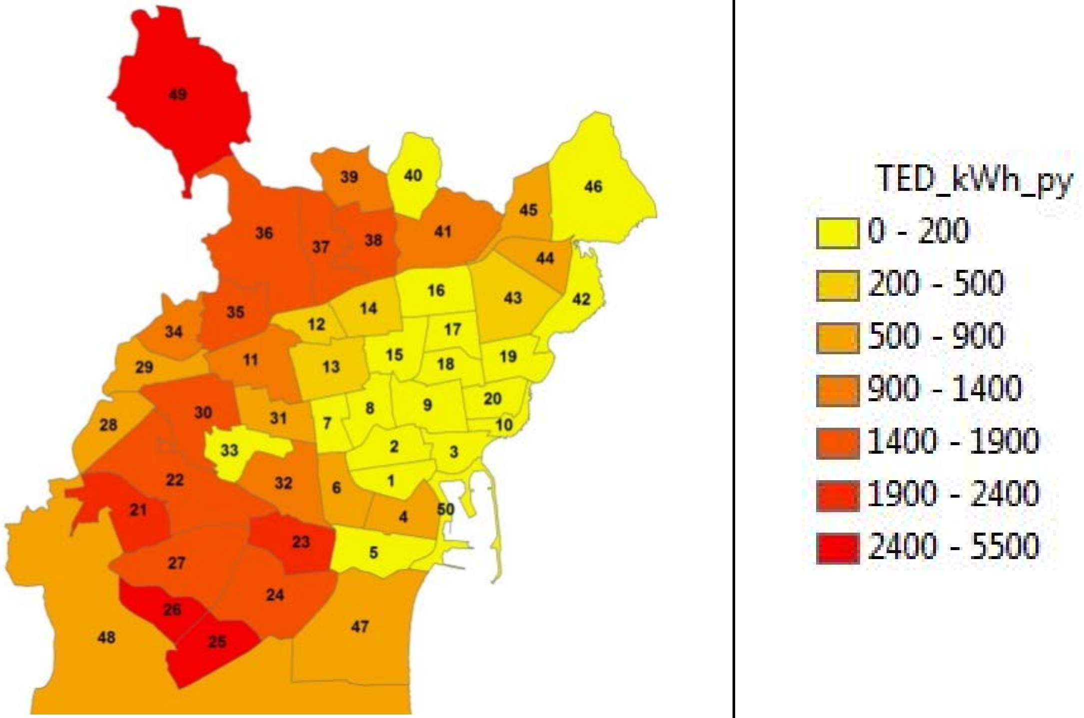


Transport Energy Dependence for different purposes

TED^{study} (kWh/student/year)



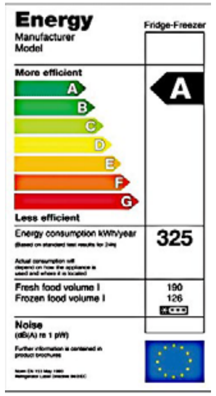
TED^{work}(kWh/worker/year)

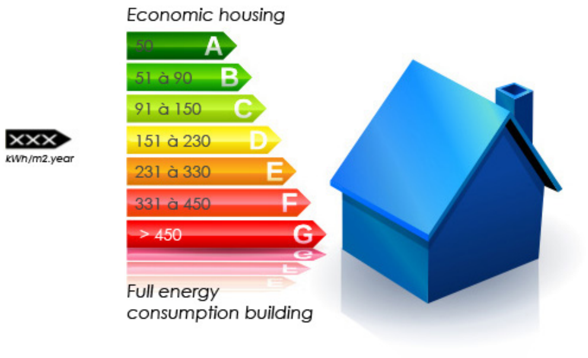


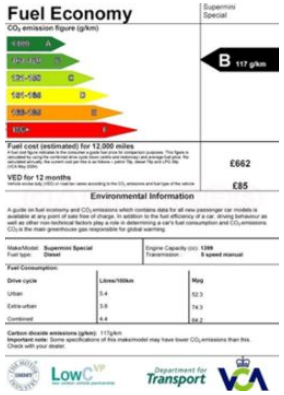
Conclusions (1/2)

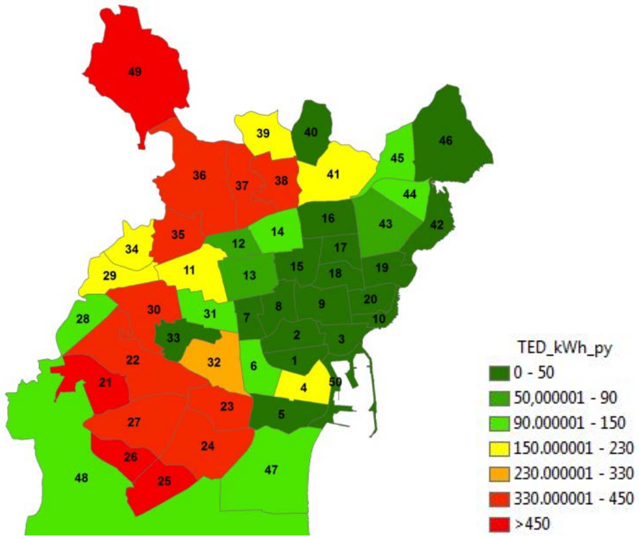
- Method that integrates **land use, transport and energy models** to evaluate the Transport Energy Dependence (TED) of a city
- Case study of the urban area of Catania to evaluate the transport energy required for **home-to-school/university trips** and to assess the impacts of different planning scenarios
- Results show the sensitivity of the model to assess the cumulative effects of different policies: density, functional mix, public transport accessibility and performance or vehicle energy efficiency
- It does not calculate the actual transport energy consumption of a city or a neighboroughood but if a planning scenario is consistent with the sustainability objectives
- The method could part of the Energy Assessment of urban plans (land use, transport or energy plans (e.g. SEAP)), where **TED standards** might have been fixed as target for their **approval**

Conclusions (2/2)









Further research

- Higher resolution zoning
- Explict representation of pedestrian and cycling network
- Different categories of workers and jobs
- Non commuting mobility (shopping, etc.)
- Better transit accessibility measures
- Test the model in ideal contexts of urban form, land use, transport and vehicle fleets
- Accessbility – transport energy coorelations

ACKNOWLEDGMENTS

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About SPECIAL

A European partnership – building the capacity of Town Planning Associations to plan and deliver sustainable energy solutions

Spatial planning has a key role to play in creating urban environments that support less energy-intense lifestyles and communities. Spatial planning and urban planners have a pivotal role in developing energy strategies and actions plans, and the SPECIAL project has been set up to help bridge the gap between climate change/energy action planning and spatial and urban planning.

SPECIAL's key objectives

1. To build the capacity of partner Town Planning Associations (TPAs), or their equivalent, to integrate sustainable energy solutions into spatial planning training, practice and delivery.
2. To foster the exchange of experience and competence-building among national and regional TPAs, to demonstrate the integration of sustainable energy into spatial planning strategies at local and regional levels.
3. To stimulate the improved energy-related competence of town planners working within local authorities, leading to good practice examples of integrated spatial planning strategies for low-carbon towns and regions.

The SPECIAL partners

The SPECIAL partners represent the professional Town Planning Associations of their respective countries:

Austria
Provincial Government of Styria, Department of Spatial Planning Law

Germany
German Institute of Urban Affairs

Greece
Organisation for the Master Plan and Environmental Protection of Thessaloniki (ORTH)

Hungary
Hungarian Urban Knowledge Centre

Ireland
Irish Planning Institute

Italy
National Centre for Town Planning Studies

Sweden
Swedish Society for Town and Country Planning

UK
Town and Country Planning Association (TCPA)

SPECIAL...

To find out more about SPECIAL, visit www.special-eu.org or contact:

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SPATIAL PLANNING and ENERGY for COMMUNITIES IN ALL LANDSCAPES

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http://www.special-eu.org/

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