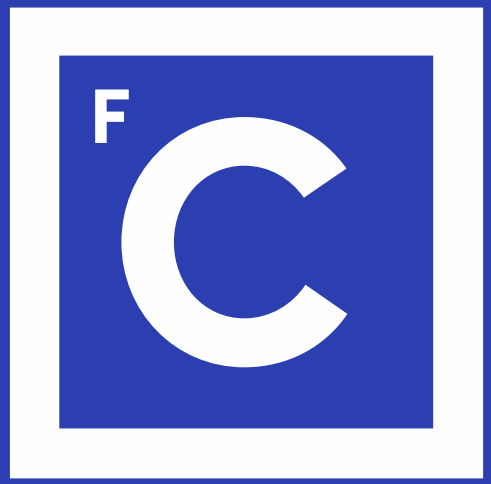


Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2019

Sustainable Mobility

1st semester

1.º Semestre

Inscrições e escolha de horários	03-09-2019	a	06-09-2019
Inscrições (1.º ano/1.ª vez)	09-09-2019	a	13-09-2019
Período de aulas (c/ 1.º ano)	**16-09-2019**	**a**	**20-12-2019**
Férias de Natal	23-12-2019	a	03-01-2020
Pausa letiva	04-01-2020	a	08-01-2020
Exames de Época Normal	**09-01-2020**	**a**	**21-01-2020**
Pausa letiva	22-01-2020	a	27-01-2020
Exames de Recurso	**28-01-2020**	**a**	**08-02-2020**
Pausa entre semestres	09-02-2020	a	16-02-2020

Lecturers

Carla Silva camsilva@ciencias.ulisboa.pt

Theory & practice 1.3.33A

Monday 14h-16h

Wednesday 16h30-18h

Program

# weeks	Content
1	Definition of sustainability in transports; Transports classification; historical evolution; surveys
2	Transport sector share energy emissions; Energy conversions, primary energy, final energy, useful energy; Minimum energy and emissions in mobility, characterization of mobility patterns ;surveys
3	Propulsion technologies, internal combustion engines, electric motors, fuel cells, local and global emissions
4	World Health Organization, Directives, standards for emissions, air quality index
5	Emission inventory models, micro to macro, motor vehicle dynamics
6	Air quality networks Measurement equipment-APA Qualar-Airpointer-QART
7	Comparing Lisbon and Oporto mobility
8	Comparing Lisbon and Oporto mobility
9	Life cycle analysis
10	Water, land use, resources scarcity and carbon footprint
11	Carbon footprint in transport
12	Carbon footprint in transport eletric versus diesel
13	SIG and Sustainable Mobility
14	SIG and Sustainable Mobility

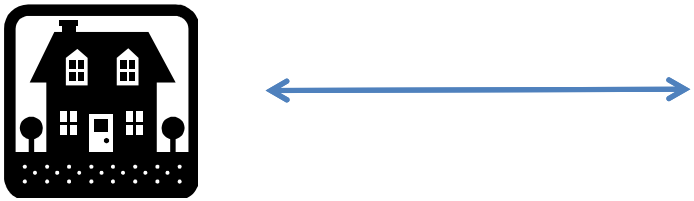
Evaluation: 2 assignements + oral

Survey + CO2eq footprint home-FCUL-home	**pdf&excel due 10 November**
Eletric car versus Diesel car	pdf&excel due 10 December
Sugested problems	voluntary
Oral exam	Works and sustainable mobility contents

Program

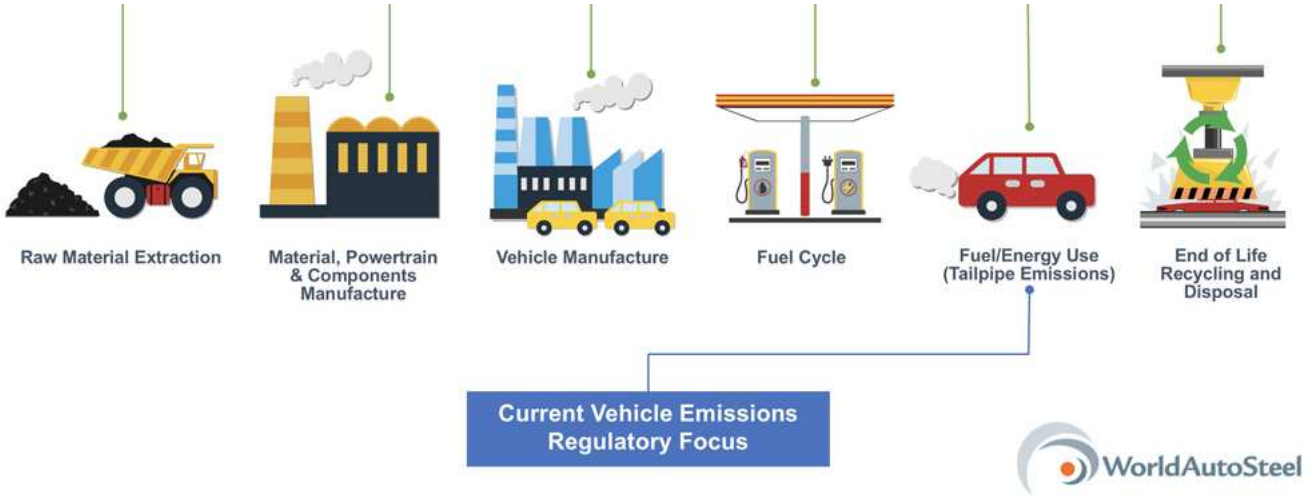
Assignement#1: Commuting home-FCUL

- CO2eq emissions
- Air quality related emissions



Assignement#2: Eletric vs Convencional Diesel

- **GWP/CO2eq**



At the end:

- ✓ Know the contribution of the transport sector for energy consumption of fossil and renewable origin and know its contribution to emissions;
- ✓ Distinguish between local and global emissions;
- ✓ Know typical values of energy consumption MJ/(p.km) and emissions g/(p.km);know how to design a survey about mobility patterns;
- ✓ Know the different technologies available and its share in the fleets;
- ✓ Know how to do an emission inventory;
- ✓ Know how to analyze scenarios and impacts on energy and emissions;
- ✓ Compare different transport system in a life cycle perspective;
- ✓ Estimate carbon footprints.

Literature

1. Black, W. R. Sustainable Transportation: Problems and Solutions. 2010. The Guilford Press.
2. Harvey, L. D. Danny . Energy Efficiency and the Demand for Energy Services. 2010. Earthscan.
3. EU Energy, Transport and GHG emissions trends to 2050. European Comission. 2013.
4. EMEP/EEA air pollutant emission inventory guidebook – 2013. European Environmnent Agency.
5. John Heywood. Internal Combustion Engine Fundamentals. 1988. McGraw-Hill.
6. Larminie, J. and Lowry, J. Electric Vehicle Technology Explained. 2012. Wiley.
7. M.K. Gajendra Babu,K.A. Subramanian Alternative Transportation Fuels: Utilisation in Combustion Engines. 2013. CRC Press.

Related events

Council **Directive 96/62/EC** of 27 September 1996 on ambient air quality assessment and management

2001 European day w/ou cars

16 - 22 September European mobility week

relacionada com a qualidade do ar das nossas cidades. Tendo em conta os crescentes problemas relacionados com o uso do automóvel

https://lisboaenova.org/conferencia-wise-mobility-2/


CONFERÊNCIA
// WISE MOBILITY
Cidades ativas, cidades saudáveis
LISBOA
SEMANA EUROPEIA DA MOBILIDADE
20 SETEMBRO //
PROGAMA //
Fundação EDP-Central Tejo
Sala dos Geradores
A mobilidade nas cidades tem um impacto direto na qualidade de vida dos cidadãos. O peão no centro do desenho do espaço público e a promoção do transporte público e de modos de deslocação ativos, permite construir uma cidade mais inclusiva, saudável e segura. A obesidade infantil, as doenças respiratórias e sinistralidade rodoviária, sem esquecer os efeitos das alterações climáticas, são consequências de modelos de cidades desenhadas para o automóvel, que imperaram no século XX.
As cidades precisam de mudar? Devemos repensar a forma como nos deslocamos? Qual o modelo de mobilidade noutras cidades?
Uma conferência que junta cidadãos e especialistas para debater mobilidade, saúde e qualidade de vida.
15h00 Sessão de abertura
Câmara Municipal de Lisboa (a definir)
15h30 Tendências tecnológicas para o futuro
Scott Shepard – Diretor Comercial, Free2Move
A estratégia da bicicleta em Londres
André Neves – Especialista em mobilidade sustentável, Transport for London
A cidade na 1ª pessoa
Miguel Somsen – Jornalista freelancer
As vivências das crianças no espaço público
Frederico Lopes – Investigador, Faculdade de Motricidade Humana - Universidade de Lisboa e Brinconauta, 1,2,3 macaquinho do Xinês
Moderador: João Pedro Pincha – jornalista
17h00 Sessão de encerramento
Miguel Gaspar – Vereador da CML
17h30 Sunset
Cocktail na Praça do Carvão
CAMINHA CONNOSCO
ORGANIZAÇÃO
LISBOA
Inscrições gratuitas e obrigatórias Aqui.

Workshop

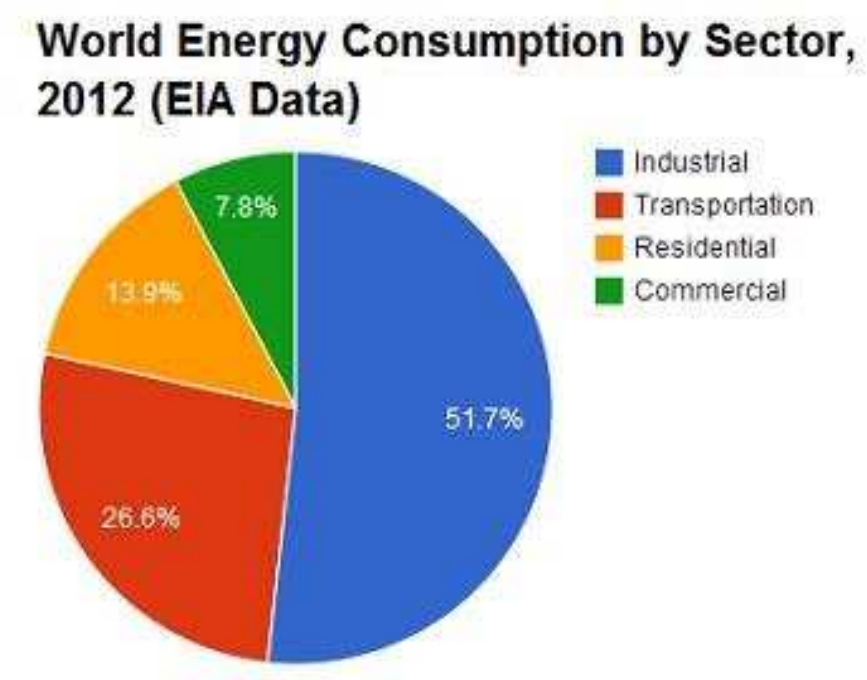
"Mobilidade Elétrica para a melhoria da qualidade do ar nas cidades"

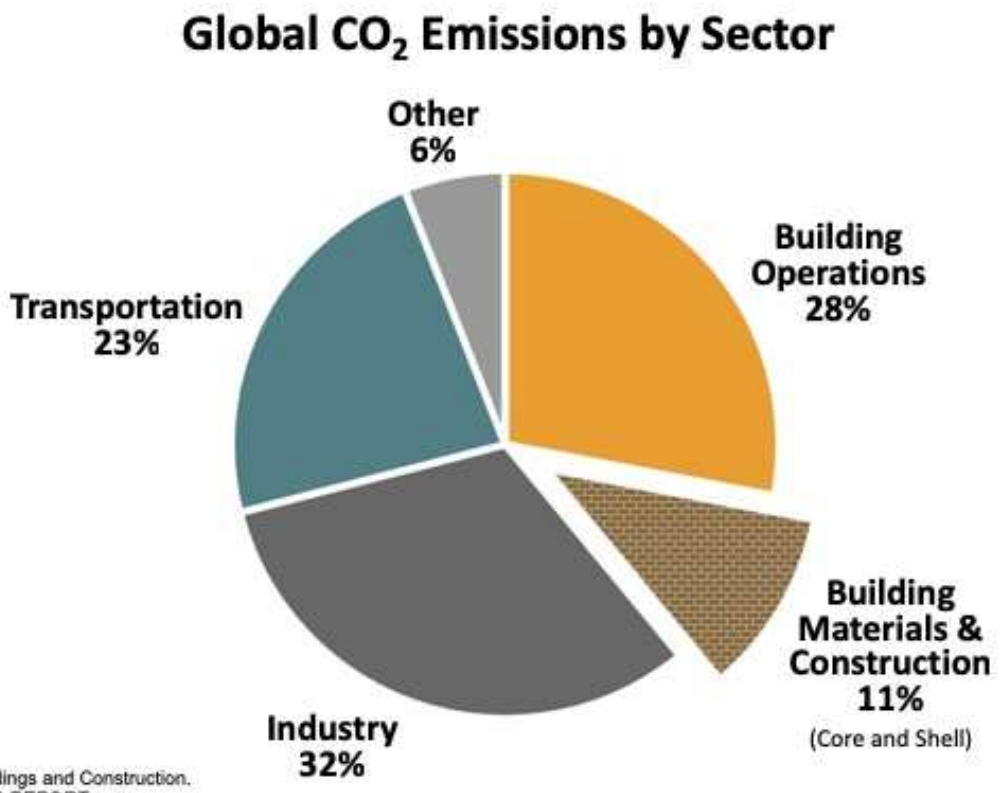
Almada, 20 Setembro 2019 • 9h30 – 12h45

Este evento integra a **Semana Europeia da Mobilidade 2019** de Almada e terá lugar no próximo dia **20 Setembro 2019**, das **9h30 às 12h40,** no Auditório da Biblioteca da Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa, no Campus de Caparica (indicações de acesso, em anexo).

As inscrições são gratuitas mas obrigatórias, devendo ser feitas até 19 de Setembro, para o e-mail dulce.lopes@ageneal.pt.

Should we worry about transportation sector?

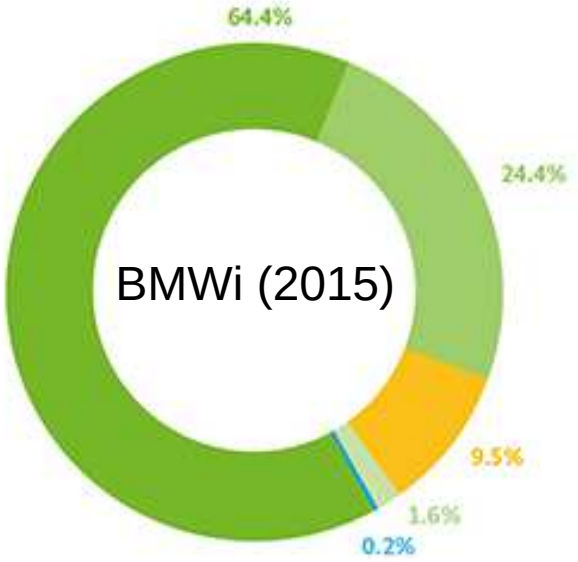




Source:
Global Alliance for Buildings and Construction.
2018 GLOBAL STATUS REPORT.

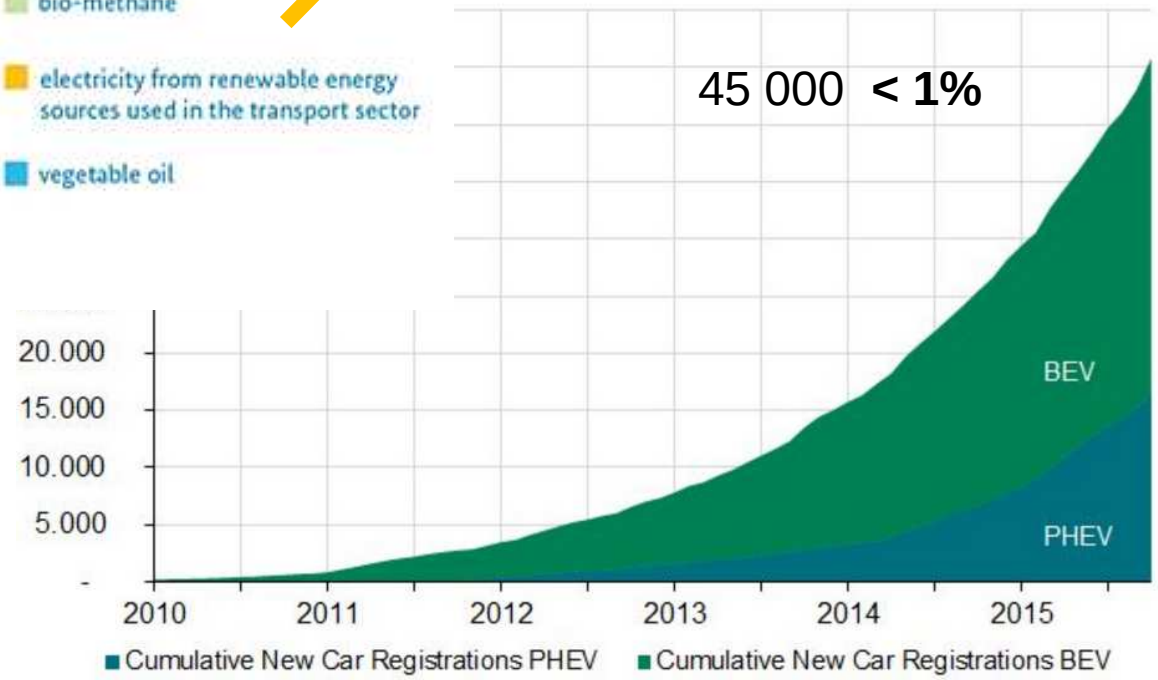
….yes

In 2014, 5.4 per cent of the energy needs in the transport sector were covered by renewables

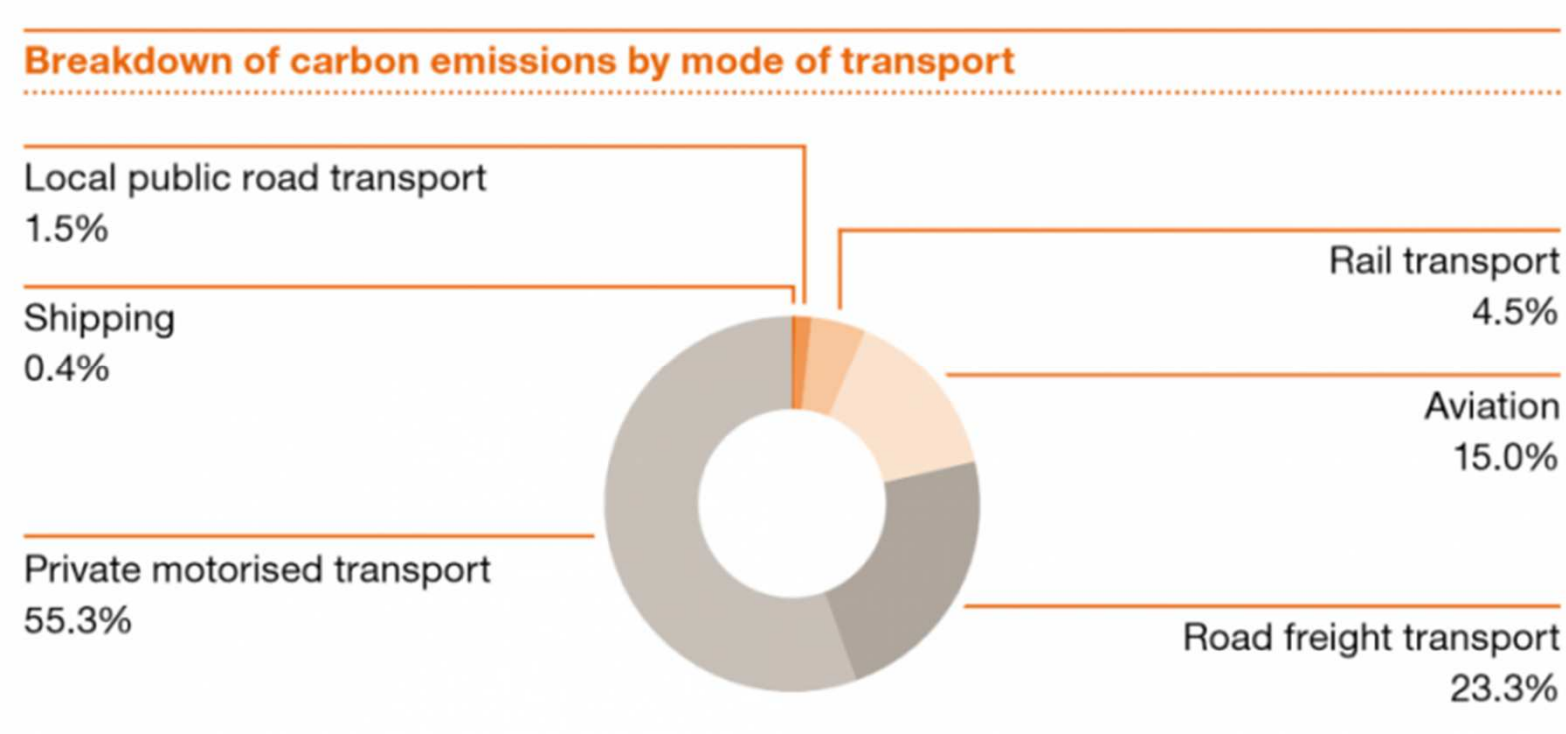


Train
Subway
Couple of electric cars
< 10%

45 000 **< 1%**



Should we worry about transportation sector?

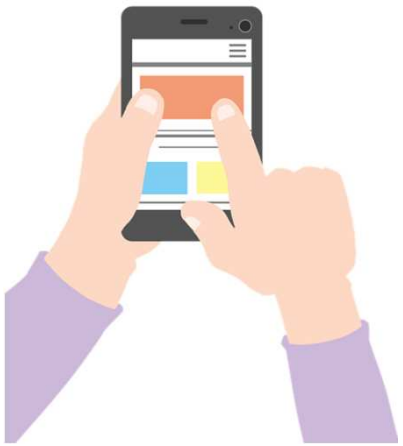


….yes

Germany
PWC (2015)

PRIVATE

How to compare cities' mobility? Aiming to improve…..identify best practices….



- **Q1 for the question pool:**

WHAT IS SUSTAINABLE MOBILITY?

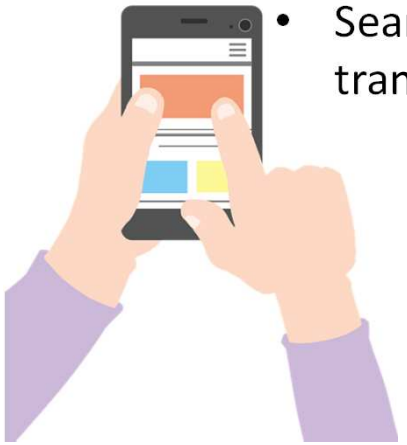
Carla Silva camsilva@fc.ul.pt

WHAT IS SUSTAINABLE MOBILITY?

- Electric vehicles;
- Affordable transportation;
- Walking & biking;
- No emissions;
- Seamless, Integrated and shared transport;

PollEv.com

carlasilva821



Poll Everywhere

Modes of transport

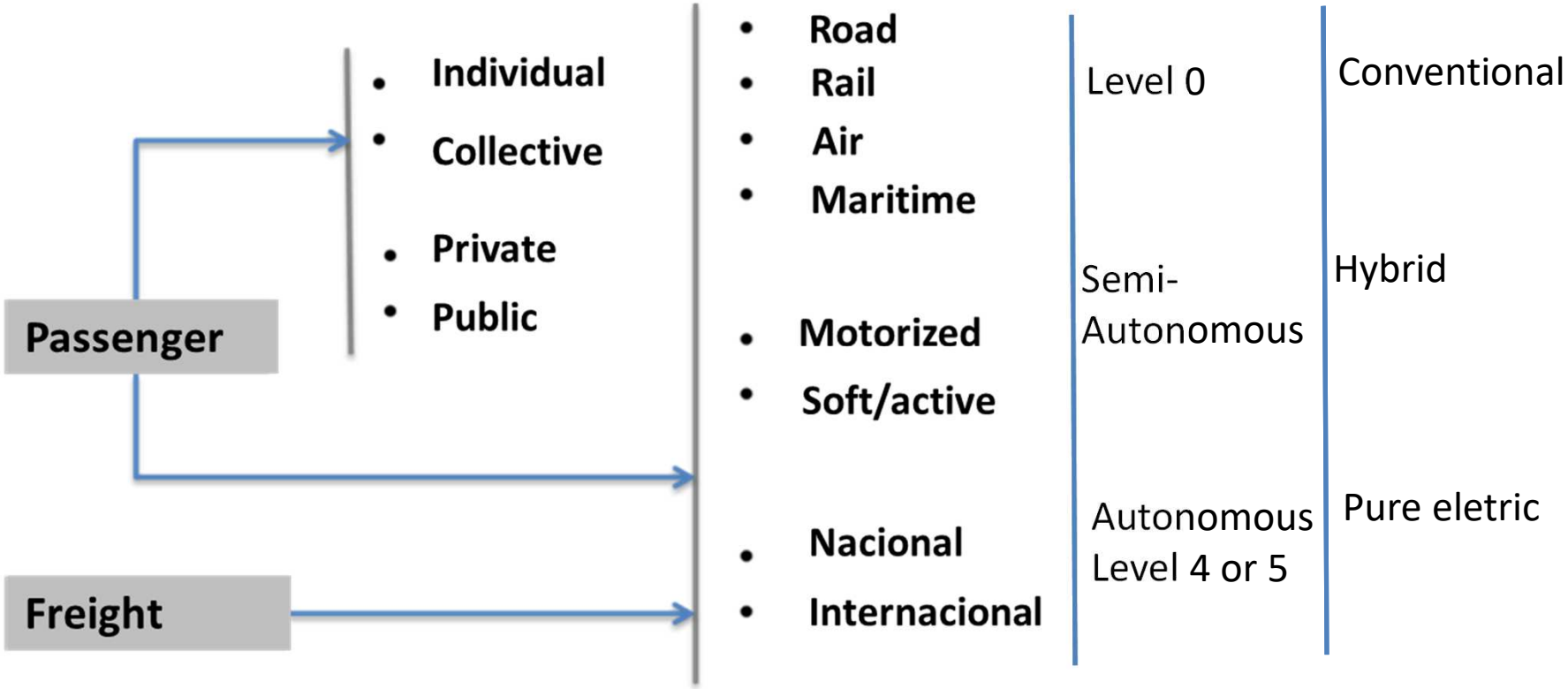
Modes….

- Passengers and freight, air, road, rail, maritime





Classification….



Classification….

Soft modes (or active modes)

Classification….

e.g. *bike-sharing* individual passenger transportation, public, road (motorized in case of eletric bikes)

Disrupting the car in Lisbon!

Lisbon

October 2017

Feb 2019

Sep 2018

140 stations, 1410 bikes

Apr 2019

Hive, Bungo, Iomo,Voi,Tier, Flash, Wind, Bird

(750 EV bikes)

~ 2000 bike
~ 2000 scooter

Carla Silva camsilva@fc.ul.pt

Classification….

e.g. táxi individual motorized

Uber individual motorized

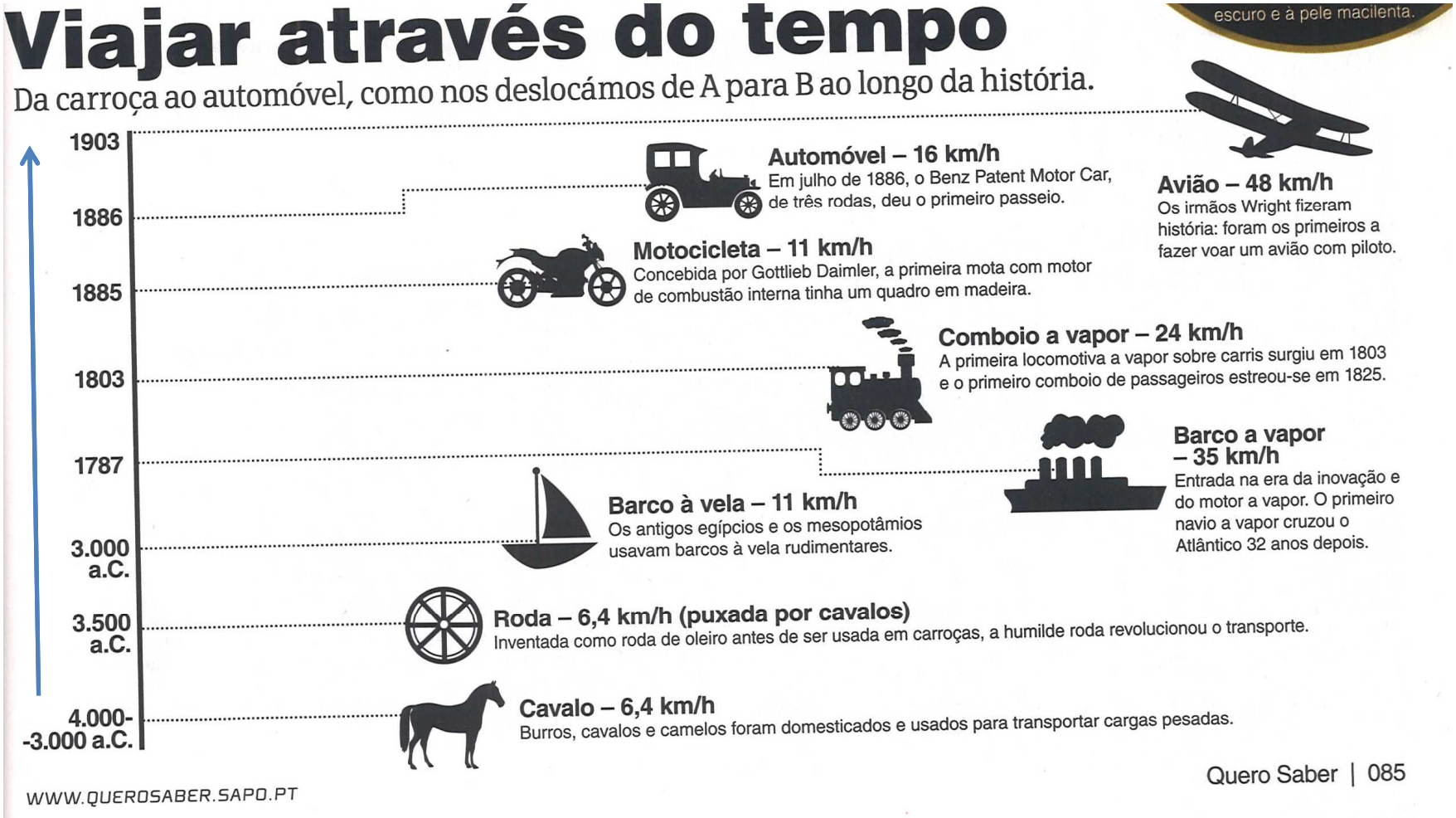
Classification….

e.g. bus colective, public, road, motorized

Classification….

e.g. *car-sharing* individual, road motorized

Speed/motorization



History…..and…future

~ Year 1859

7 days 34 h

New road influence

~ Year 1864

14h 1st train

~ Year 2000

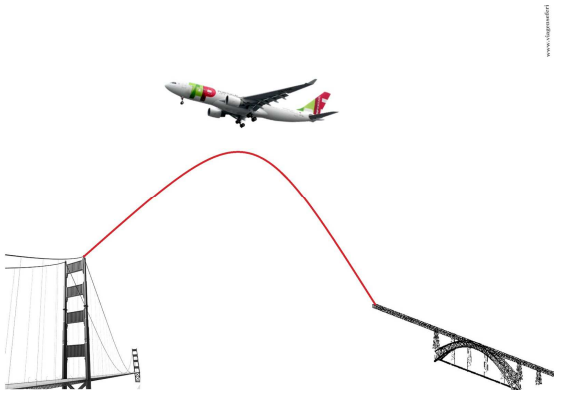
2h35 Alfa Pendular

~ Year 2016

<1h Airplane

History…..and…future

VS



What mode of transport is more sustainable?

https://rr.sapo.pt/2017/03/28/reportagem/lisboa-porto-aviao-ou-comboio-qual-a-melhor-opcao-fizemos-o-teste/video/132412/

History…..and…future

New York on the 1800's

History…..and…future

Lisbon on the 1800's, CARRIS carriage

History…..and…future

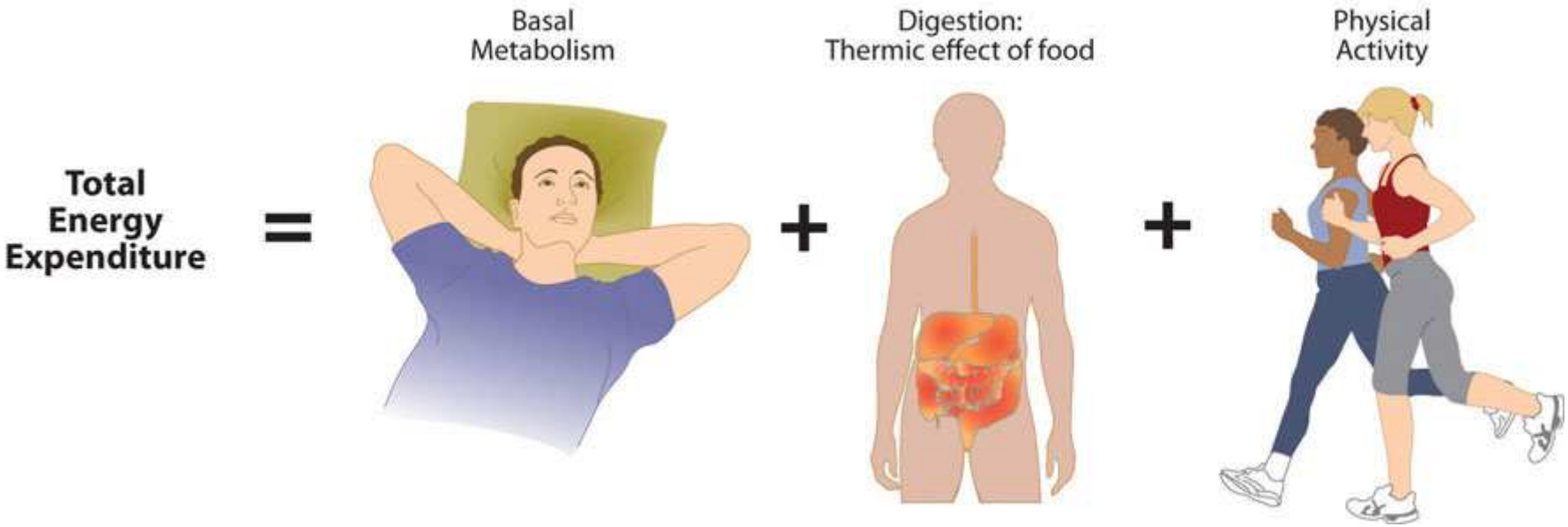
Lisbon Av. 24 Julho 1912, CARRIS electric tram

History…..and…future

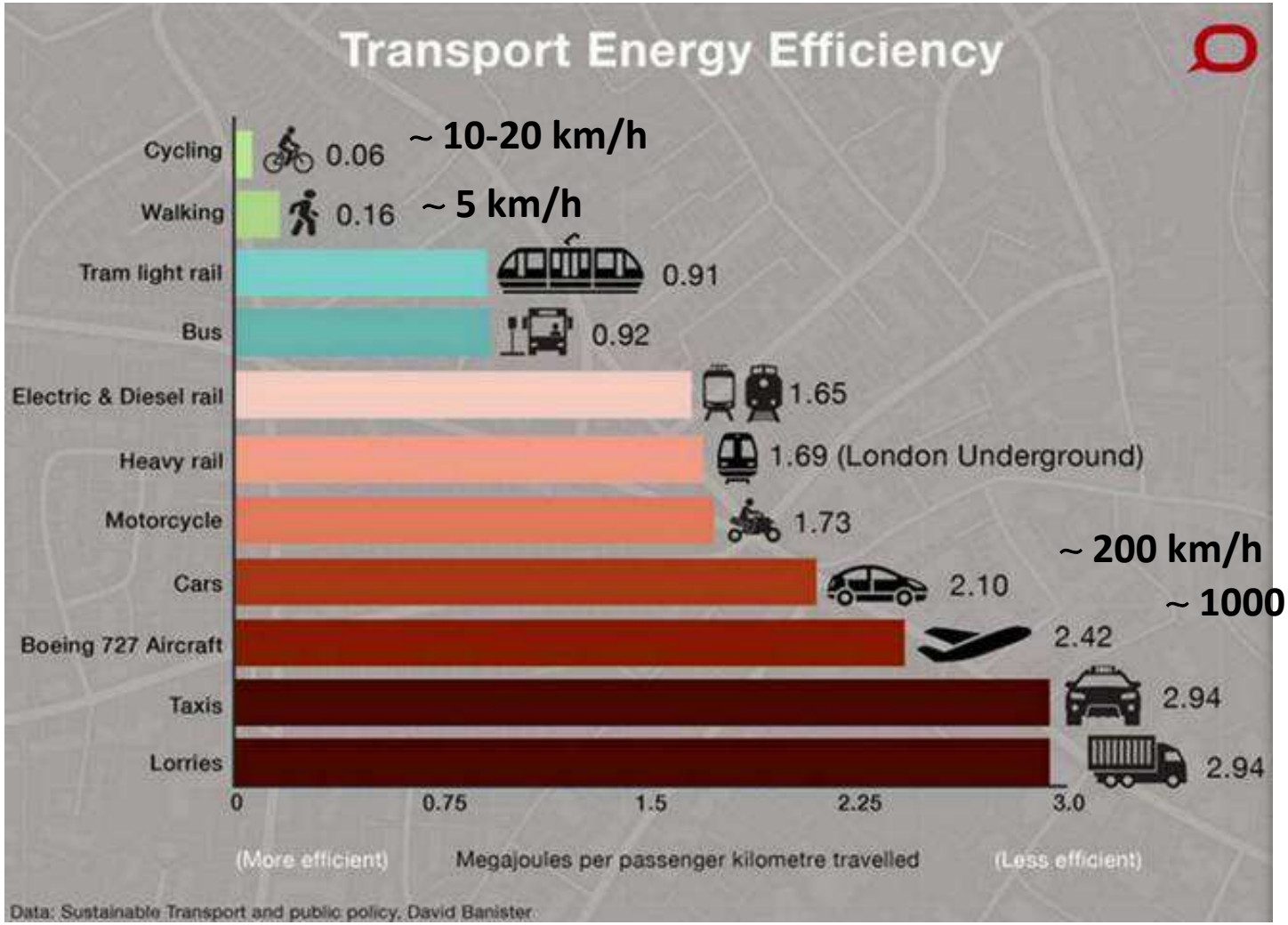
Walk….always….Energy????

History…..and…future

Walk….always….Energy????



History…..and…future



Sustainability

Sustainability

William R. Black
Department of Geography, Indiana University, Bloomington, Indiana 47405, USA

“transport that meets the current transport and mobility needs without compromising the ability of future generations to meet these needs” Black, 1996

“a more sustainable transportation system” as “one which provides affordable access to freight and passenger service and does so in an environmentally sound and equitable manner”

Black, 2010, from “Department transportation Canada, 2003”

What is sustainable mobility?

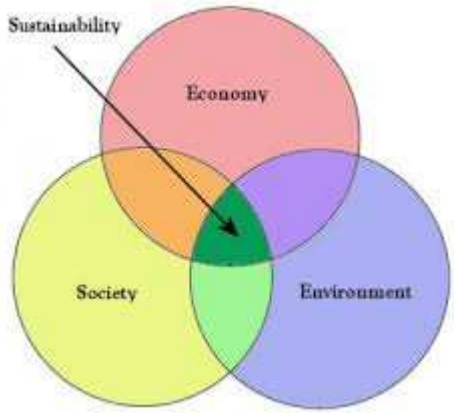
Satisfy the needs of access/mobility

Compatible with the health of human being and ecosystems

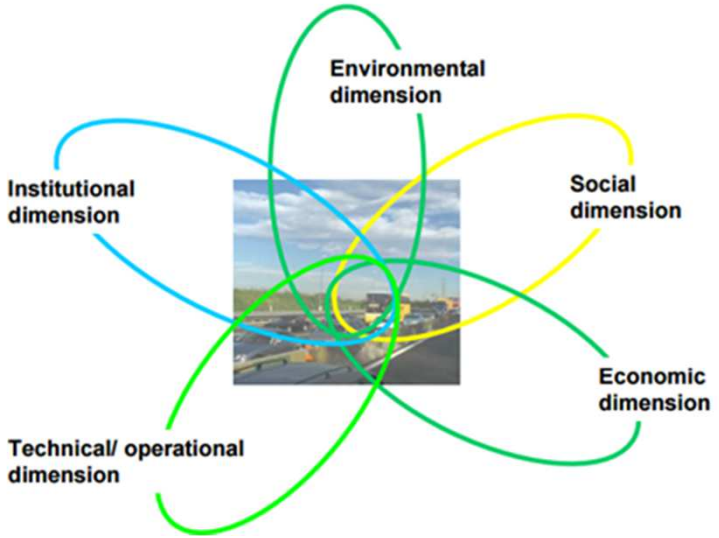
Affordable, efficient, endorse model choice and supports a dynamic economy and local development

Reduce fossil fuel usage, reuse and recycle its materials, produce low noise and has low land use

Sustainability indicators



✓Planning
✓Mobility management



7 INDICATORS

A – Transportes Públicos
B – Mobilidade Pedonal e Acessibilidade
C – Mobilidade Ciclável
D – Planos e Projetos
E – Acalmia de Tráfego
F – Sensibilização

APA, 14 de Fevereiro de 2012

Instituto da Mobilidade e dos Transportes Terrestres, I.P.

55 Indicators– Joint Research Centre

JRC EUROPEAN COMMISSION

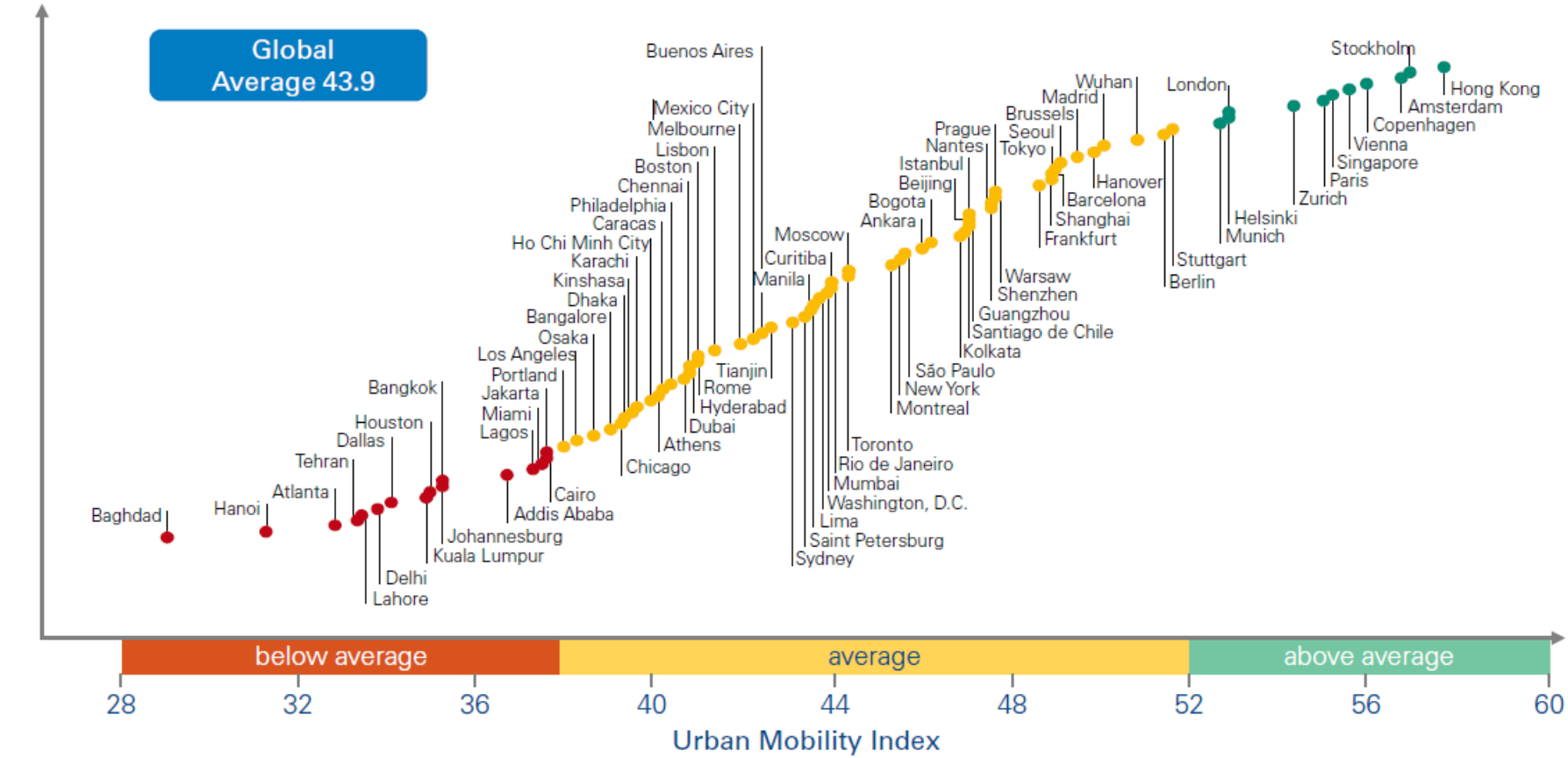
What is sustainable mobility?

UITP ADVANCING PUBLIC TRANSPORT

What is sustainable mobility?

Figure 6: Arthur D. Little' Urban Mobility Index 2.0

19 INDICATORS



Source: Arthur D. Little Urban Mobility Index 2.0; UITP is independent of this index, which does not necessarily reflect its opinion; 100 index points for city that would achieve best performance on each criteria.

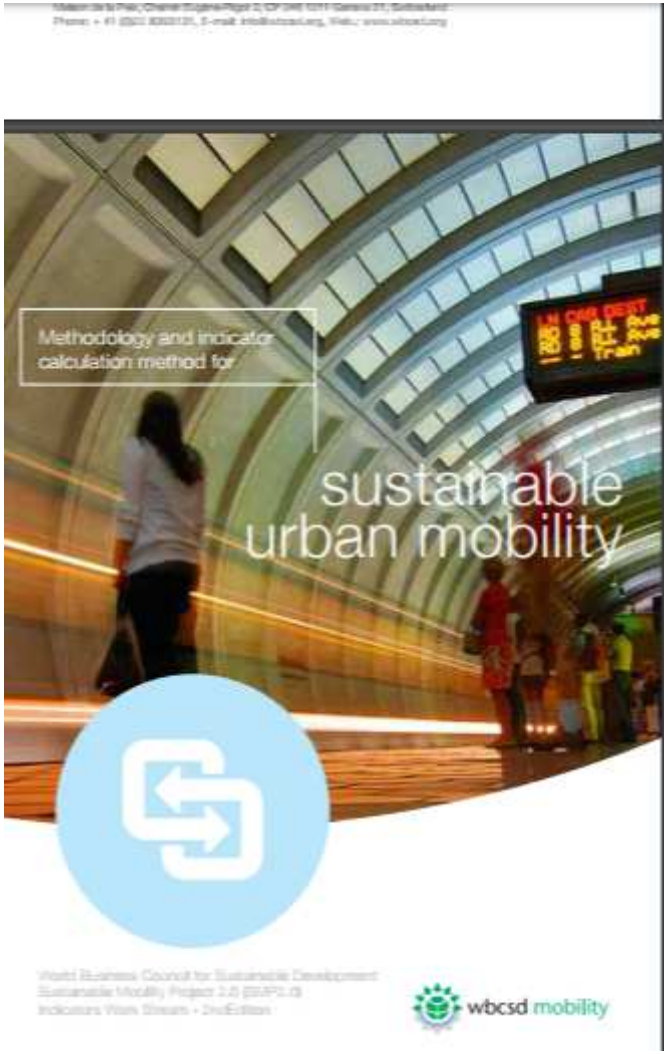
What is sustainable mobility?

Figure 8: Top 11 cities with above average mobility score

		Maturity indicators											Performance indicators							
		Fin. attract. of PT (cost of 5 km PT/ cost of 5 km car)	Share of public transport in modal split [%]	Share of zero-emission modes in modal split [%]	Roads density (deviation from optimum) [km/km^2]	Cycle path network density [km/ths km^2]	Urban agglomeration density [citizens/km^2]	Smart card penetration [cards/capita]	Bike sharing performance [shared bikes/ million citizens]	Car sharing performance [shared cars/million citizens]	Density of vehicles registered [vehicles/capita]	Frequency of the busiest public transport line [times/ day]	Initiatives of public sector (0 to 10 scale)	Transport related CO_2 emissions [kg/capita]	Annual average NO_2 concentration [mcg/m^3]	Annual average PM_{10} concentration [mcg/m^3]	Traffic related fatalities per 1 million citizens	Dynamics of share public transport in modal split [%]	Dynamics zero-emission modes in modal split [%]	Mean travel time to work [minutes]	OVERALL SCORE
1	Hong Kong	1.7	55%	38%	2.0	187	6.5	3.1	0	0	0.07	324	10	776	50.0	50.0	16.2	+20%	0%	36.6	58.2
2	Stockholm	6.7	33%	34%	0.5	4,041	3.7	0.6	852	400	0.40	212	10	1,348	12.5	16.7	9.4	-7%	+89%	33.7	57.4
3	Amsterdam	3.0	8%	50%	1.7	3,502	3.2	0.7	527	1,219	0.32	130	10	844	30.0	24.7	19.5	+12%	+13%	35.5	57.2
4	Copenhagen	4.8	27%	33%	2.7	3,977	2.7	0.1	1,025	246	0.24	238	10	812	56.0	28.0	4.1	+123%	-15%	29.7	56.4
5	Vienna	3.9	39%	34%	0.6	2,948	3.8	0.0	692	415	0.39	277	10	1,111	21.7	21.5	16.1	+15%	+13%	29.3	56.0
6	Singapore	2.6	48%	23%	2.6	280	7.3	2.9	19	57	0.18	233	9	1,381	22.0	29.0	32.5	+17%	+64%	36.8	55.6
7	Paris	2.9	34%	50%	8.8	3,520	3.8	0.6	2,224	219	0.46	267	10	1,163	39.2	38.0	23.9	+7%	0%	38.6	55.4
8	Zurich	3.8	39%	31%	0.7	3,700	4.2	0.0	232	1,064	0.54	149	10	1,200	30.1	19.1	15.4	+15%	+3%	30.4	54.7
9	London	3.9	34%	26%	10.8	254	5.6	3.1	1,012	253	0.39	468	10	1,050	37.0	22.9	26.6	+10%	+4%	44.1	53.2
9	Helsinki	3.6	27%	40%	2.1	4,678	2.3	0.9	0	70	0.48	246	10	1,228	28.0	20.2	13.9	-16%	+8%	28.5	53.2
11	Munich	4.6	21%	42%	0.1	3,862	3.0	0.0	727	640	0.56	210	10	1,351	35.3	21.7	15.3	0%	+11%	30.1	53.0

Source: Arthur D. Little Urban Mobility Index 2.0

What is sustainable mobility?



World Business Council for Sustainable Development

Sustainable Mobility Project 2.0 (SMP2.0) Indicators Work Stream - 2nd Edition

http://wbcsdpublications.org/wp-content/uploads/2016/01/SMP2.0_Sustainable-Mobility-Indicators_2ndEdition.pdf

What is sustainable mobility?

World Business Council for Sustainable Development

"Sustainable mobility is the ability to meet society's need to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future."

(Source WBCSD, Mobility 2030: Meeting the challenges to sustainability, 2004)

What is sustainable mobility?

DIMENSIONS vs ***INDICATORS***

Accessibility for mobility impaired groups	Accessibility for impaired	S	Q
Air polluting emissions	Air pollution	Q	
Noise hindrance	Noise hindrance	Q	
Fatalities	Fatalities	Q	
Access to mobility services	Access	Q	
Quality of public area	Public area	Q	
Urban Functional diversity	Functional diversity	Q	E
Commuting travel time	Travel time	Q	E
Economic Opportunity	Economic Opportunity	Q	E
Net public finance	Public Finance	E	
Mobility space usage	Space Usage	G	E
Emissions of greenhouse gases (GHG)	GHG	G	
Congestion and delays	Congestion	G	S
Energy efficiency	Energy efficiency	G	S
Opportunity for active mobility	Active mobility	G	S
Intermodal integration	Intermodal integration	S	
Comfort and pleasure	Comfort and pleasure	S	Q
Security	Security	S	Q

Table.1: Overview of the 19 Sustainable Urban Mobility Indicators indicating the dimensions of the sustainability of the mobility system. Source: Oran Consulting for WBCSD SMP2.0, 2014

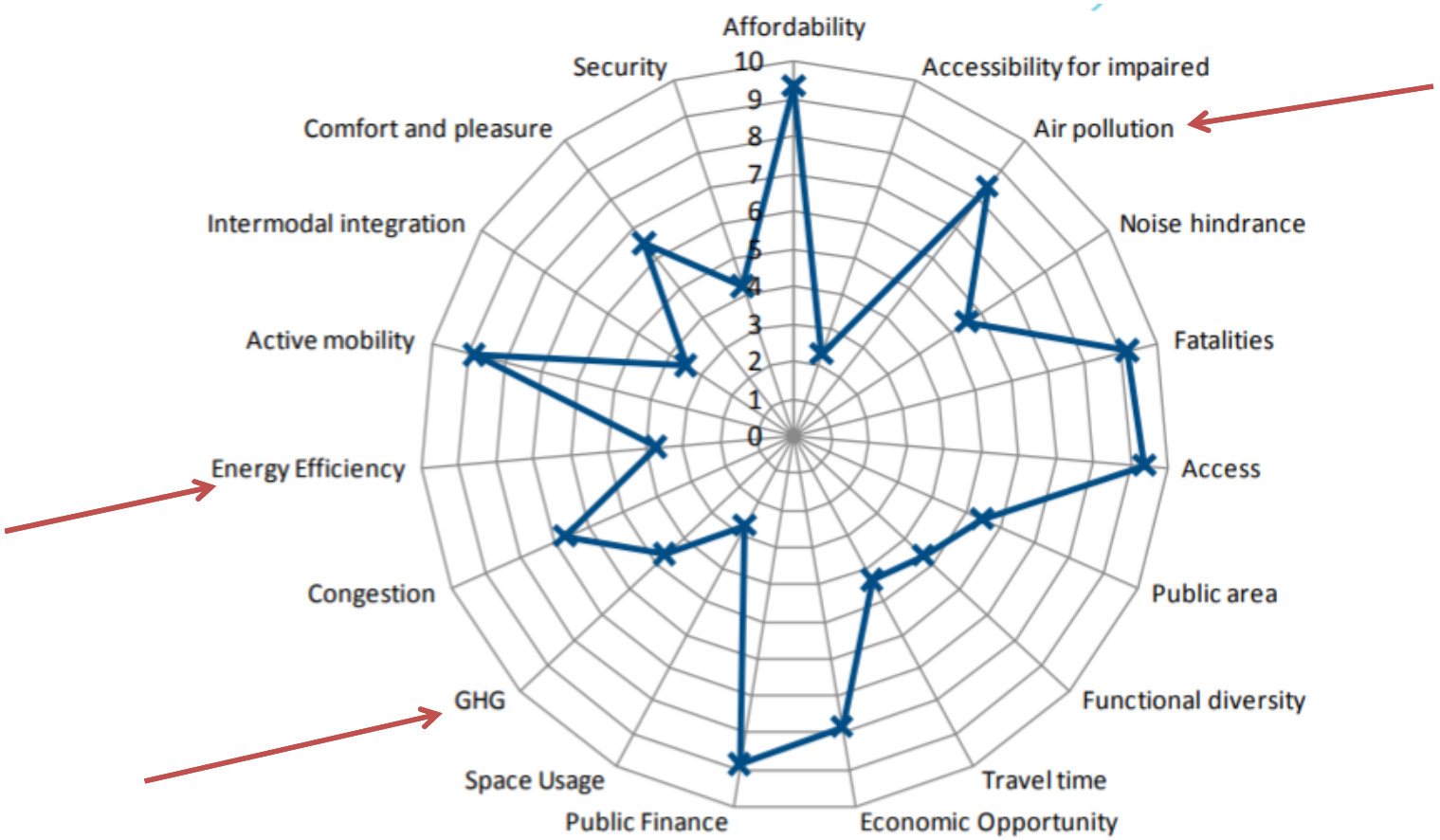
Three dimensions refer to the sustainability of the resource use and/or the impacts of mobility in the city:

- G — Global environment
- Q — Quality of life
- E — Economic success
- S — Mobility system performance

4 dimensions- 19 Indicators

What is sustainable mobility?

19 INDICATORS



Indicators of sustainable Mobility

19 INDICATORS

Table 34 **Key Sustainable Transport Goals, Objectives and Indicators**

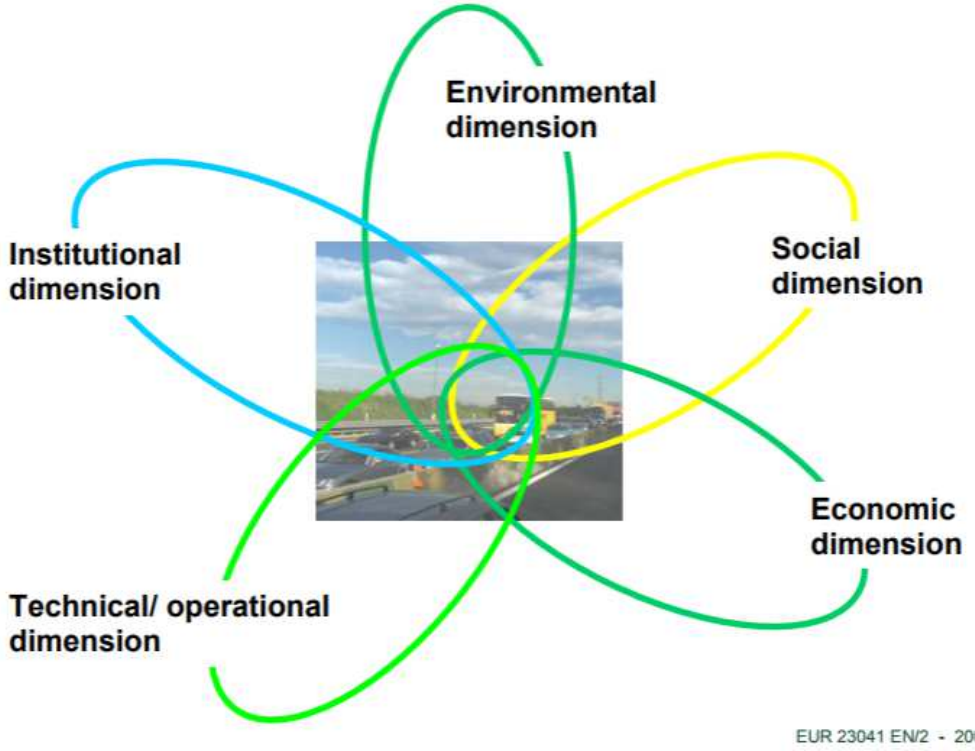
Sustainability Goals	Objectives	Performance Indicators
I. Economic		
Economic productivity	Transport system efficiency. Transport system integration. Maximize accessibility. Efficient pricing and incentives.	• Per capita GDP and income. • Portion of budgets devoted to transport. • Per capita congestion delay. • Efficient pricing (road, parking, insurance, fuel, etc). • Efficient prioritization of facilities (roads and parking).
Economic development	Economic and business development	• Access to education and employment opportunities. • Support for local industries.
Energy efficiency	Minimize energy costs, particularly petroleum imports.	• Per capita transport energy consumption • Per capita use of imported fuels.
Affordability	All residents can afford access to basic (essential) services and activities.	• Availability and quality of affordable modes (walking, cycling, ridesharing and public transport). • Portion of low-income households that spend more than 20% of budgets on transport.
Efficient transport operations	Efficient operations and asset management maximizes cost efficiency.	• Performance audit results. • Service delivery unit costs compared with peers. • Service quality.
II. Social		
Equity / fairness	Transport system accommodates all users, including those with disabilities, low incomes, and other constraints.	• Transport system diversity. • Portion of destinations accessible by people with disabilities and low incomes.
Safety, security and health	Minimize risk of crashes and assaults, and support physical fitness.	• Per capita traffic casualty (injury and death) rates. • Traveler crime and assault rates. • Human exposure to harmful pollutants. • Portion of travel by walking and cycling.
Community development	Help create inclusive and attractive communities. Support community cohesion.	• Land use mix. • Walkability and bikability • Quality of road and street environments.
Cultural heritage preservation	Respect and protect cultural heritage. Support cultural activities.	• Preservation of cultural resources and traditions. • Responsiveness to traditional communities.
III. Environmental		
Climate protectin	Reduce global warming emissions Mitigate climate change impacts	• Per capita emissions of global air pollutants (CO_2, CFCs, CH_4, etc.).
Prevent air pollution	Reduce air pollution emissions Reduce exposure to harmful pollutants.	• Per capita emissions of local air pollutants (PM, VOCs, NOx, CO, etc.). • Air quality standards and management plans.
Prevent noise pollution	Minimize traffic noise exposure	• Traffic noise levels
Protect water quality and minimize hydrological damages	Minimize water pollution. Minimize impervious surface area.	• Per capita fuel consumption. • Management of used oil, leaks and stormwater. • Per capita impervious surface area.
Openspace and biodiversity protection	Minimize transport facility land use. Encourage more compact development. Preserve high quality habitat.	• Per capita land devoted to transport facilities. • Support for smart growth development. • Policies to protect high value farmlands and habitat.
IV. Good Governance and Planning		
Integrated, comprehensive and inclusive planning	Planning process efficiency. Integrated and comprehensive analysis. Strong citizen engagement. Lease-cost planning (the most overall beneficial policies and projects are implemented).	• Clearly defined goals, objectives and indicators. • Availability of planning information and documents. • Portion of population engaged in planning decisions. • Range of objectives, impacts and options considered. • Transport funds can be spent on alternative modes and demand management if most beneficial overall.

This table summarizes sustainability goals, objectives and performance indicators.

VICTORIA Transport Policy INSTITUTE
EFFICIENCY • EQUITY • CLARITY

What is sustainable mobility?

DIMENSIONS vs ***INDICATORS***



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5 dimensions- 55 Indicators

Indicators of sustainable Mobility

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55 Indicators– Joint Research Centre

Table 1. Indicator Framework for the Evaluation of Transport Sustainability Performance

DIMENSION	THEME	RELATED INDICATORS
ECONOMIC	*Transport Demand and Intensity*	1.Volume of transport relative to GDP (tonne-km; passenger-km)
		2. Road transport (passenger and freight; tonne-km and passenger -km)
		3. Railway transport (passenger and freight; tonne-km and passenger-km)
		4. Maritime transport for goods and passengers (tonne-km and passenger-km)
		5. Inland waterway transport (passenger and freight; tonne-km and passenger-km)
		6. Air transport (passenger and freight; tonne-km and passenger-km)
		7. Intermodal transport (tonne-km and passenger-km)
	Transport Costs and Prices	8. Total per capita transport expenditures (vehicle parking, roads and transit services)
		9. Motor vehicle fuel prices and taxes (for gasoline and gas/ diesel)
		10. Direct user cost by mode (passenger transport)
		11. External costs of transport activities (congestion, emission costs, safety costs) by transport mode (freight and passenger)
		12. Internalization of costs (implementation of economic policy tools with a direct link with the marginal external costs of the use of different transport modes)
		13. Subsidies to transport
		14. Taxation of vehicles and vehicle use
		15. % of GDP contributed by transport
		16. Investment in transport infrastructure (per capita by mode/ as share of GDP)
	Infrastructure	17. Road quality - paved roads, fair/ good condition
		18. Total length of roads in km by mode

http://publications.jrc.ec.europa.eu/repository/bitstream/JRC54971/sust_transp_ind_report_final.pdf

Indicators of sustainable Mobility

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		19. Density of infrastructure (km-km^2)
SOCIAL	*Accessibility and Mobility*	20. Average passenger journey time
		21. Average passenger journey length per mode
		22. Quality of transport for disadvantaged people (disabled, low incomes, children)
		23. Personal mobility (daily or annual person-km and trips by income group)
		24. Volume of passengers
	Risk and Safety	25. Persons killed in traffic accidents (number of fatalities - 1000 vehicle km; per million inhabitants)
		26. Traffic accidents involving personal injury (number of injuries – 1000 vehicle km; per million inhabitants)
	Health Impacts	27. Population exposed to and annoyed by traffic noise, by noise category and by mode associated with health and other effects
		28. Cases of chronic respiratory diseases, cancer, headaches. Respiratory restricted activity days and premature deaths due to motor vehicle pollution
	Affordability	29. Private car ownership
		30. Affordability (portion of households income devoted to transport)
	Employment	31. Contribution of transport sector (by mode) to employment growth

Indicators of sustainable Mobility

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ENVIRONMENTAL	*Transport Emissions*	32. NOx emissions (per capita)
		33. VOCs emissions (per capita)
		34. PM_{10} and $PM_{2.5}$ emissions (per capita)
		35. SOx emissions (per capita)
		36. O_3 concentration (per capita)
		37. CO_2 emissions (per capita)
		38. N_20 emissions (per capita)
		39. CH_4 emissions (per capita)
	Energy Efficiency	40. Energy consumption by transport mode (tonne-oil equivalent per vehicle km)
		41. Fuel consumption (vehicles-km by mode)
	Impacts on Environmental Resources	42. Habitat and ecosystem disruption
		43. Land take by transport infrastructure mode
	Environmental Risks and Damages	44. Polluting accidents (land, air, water)
		45. Hazardous materials transported by mode
	Renewables	46. Use of renewable energy sources (numbers of alternative-fuelled vehicles) - use of biofuels
TECHNICAL and OPERATIONAL	*Occupancy of Transportation*	47. Occupancy rate of passenger vehicles
		48. Load factors for freight transport (LDV, HDV)
	Technology Status	49. Average age of vehicle fleet
		50. Size of vehicle fleet (vehicle/ 1 mln. inhabitants)
		51. Proportion of vehicle fleet meeting certain air emission standards (Euro IV, Euro V etc.)
INSTITUTIONAL	*Measures to Improve Transport Sustainability*	52. R&D expenditure on "eco vehicles" and clean transport fuels
		53. Total expenditure on pollution prevention and clean-up
		54. Measures taken to improve public transport
	Institutional Development	55. Uptake of strategic environmental assessment in the transport sector

Indicators of sustainable Mobility

JRC EUROPEAN COMMISSION

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- Other metrics; 4 dimensions 17 indicators

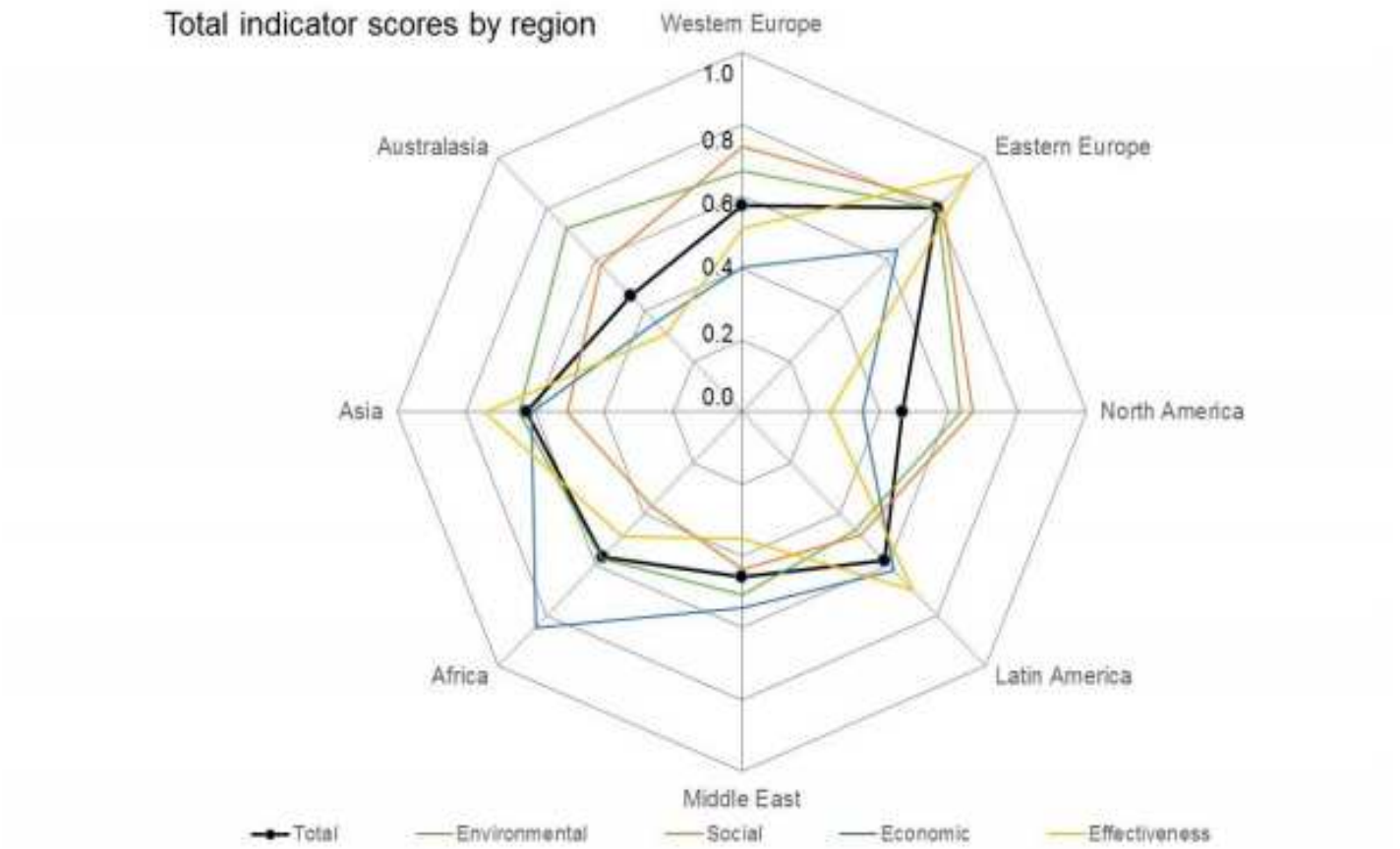
Table 1: Indicators for assessing urban public transport sustainability

ID	Indicator	Units	Desirability
A	**ENVIRONMENTAL**		
A1	Quantity of energy consumed	MJ/pkm	Less is desirable
A2	Mass of total pollutants emitted (e.g. NO_x, VOC, CO_2)	kg/ha	Less is desirable
A3	Land area consumed by public transport facilities	% of urban area	Less is desirable
B	**SOCIAL**		
B1	System accessibility	pkm/capita	More is desirable
B2	Average user trip distance	km	Less is desirable
B3	Affordability	10^{-4} per capita GDP/trip	Less is desirable
B4	Public transport related deaths	fatalities/billion-pkm	Less is desirable
C	**ECONOMIC**		
C1	Annual operating cost	$US/pkm	Less is desirable
C2	Cost recovery (proportion of costs recovered)	% of total costs	More is desirable
C3	Passenger km travelled per unit GDP	pkm/$US	More is desirable
C4	Average time per trip	mins	Less is desirable
D	**SYSTEM EFFECTIVENESS**		
D1	Average occupancy rate of passenger vehicles	% of seated capacity	More is desirable
D2	Annual public transport trips per capita	trips/capita	More is desirable
D3	Public transport mode split	% of all trips	More is desirable
D4	Public transport fleet size	vehicles/million people	More is desirable

Source: De Gruyter et al. (2017)

Chris De Gruyter , Graham Currie ,and Geoff Rose. Sustainability Measures of Urban Public Transport in Cities: A World Review and Focus on the Asia/Middle East Region. Sustainability 2017, 9, 43; doi:10.3390/su9010043

Figure 1: Aggregate Normalised Total and Category Public Transport Sustainability Indicators by World Region



- ✓ **There is no unique metric system for measuring sustainable mobility;**
- ✓ **Stick to one set of metrics and conclude on that basis!**

1 DIMENSION

11 Indicators

Environmental

Ton or g/year

Emissions per year (per capita)

NOx (NO and NO_2)	*Outdoor Air quality*
VOCs	
CO	
PM10	
PM2.5	
SOx	
O_3	
CO_2	*GreenHouse gas*
N_2O	
CH_4	

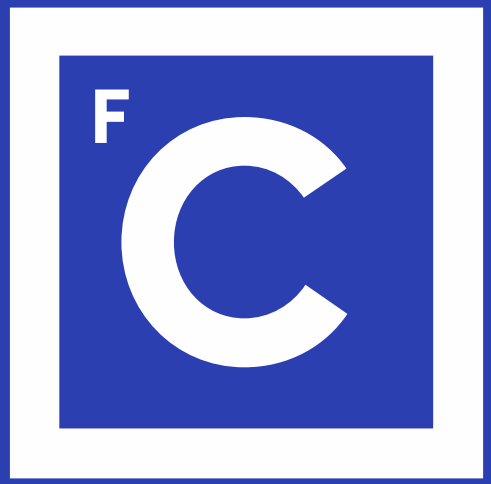
Energy consumption per year (per capita)

Most common……

You learned….

- Transport classification- examples;
- Evolution in speed-motorization;
- Energy and emissions baseline.
- What is sustainable mobility;
- Dimensions and indicators- examples;

Obrigado



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