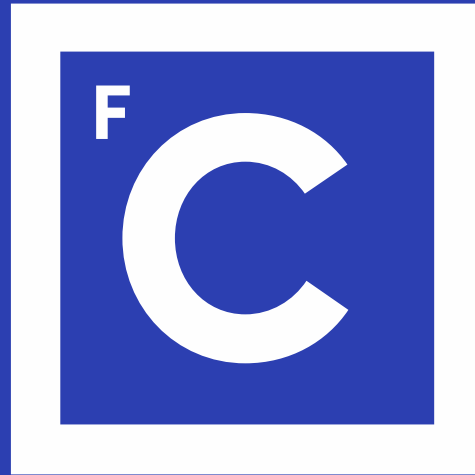




Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2018

move ► green



Mobilidade Sustentável

1st semester

1.º Semestre

Inscrições e escolha de horários	04-09-2018	a	07-09-2018
Inscrições (1.º ano/1.ª vez)	10-09-2018	a	14-09-2018
Período de aulas (c/ 1.º ano)	17-09-2018	a	19-12-2018
Férias de Natal	20-12-2018	a	02-01-2019
Pausa letiva	03-01-2019	a	09-01-2019
Exames de Época Normal	10-01-2019	a	22-01-2019
Pausa letiva	23-01-2019	a	28-01-2019
Exames de Recurso	29-01-2019	a	09-02-2019
Pausa entre semestres	10-02-2019	a	17-02-2019

Lecturers

Carla Silva (Teóricas) camsilva@ciencias.ulisboa.pt

Pedro Nunes (Práticas) pmnunes@fc.ul.pt

Theory & practice Monday 14h-16h 1.3.33A

Practice 4ª 16h-18h30 1.3.33A

Program

# Class	Content
1	Definition of sustainability in transports; Transports classification; historical evolution
2	Transport sector share energy emissions; Energy conversions, primary energy, final energy, useful energy; Minimum energy and emissions in mobility, characterization of mobility patterns P#1
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 P#2
5	Emission inventory models, micro to macro, motor vehicle dynamics P#3
6	Arduino-autonomos cars
7	Air quality networks Measurement equipment-APA Qualar-Airpointer-QART
8	EcoKart-conversion of gasoline to electric karts
9	Life cycle analysis
10	Water, land use, resources scarcity and carbon footprint
11	Carbon footprint in transport
12	Carbon footprint in transport P#4
13	Final assignment
14	Final assignment

Program

# Class	Data	Content
1		Survey
2		Survey
3		Survey
4		COPERT V
5		COPERT V
6		COPERT V
7		COPERT V
8		Arduino/project
9		Arduino/project
10		Arduino/project
11		Arduino/project
12		Arduino/project
13		Final assignement
14		Final assignement

Practice goals:

- Survey methodology to know mobility patterns and how to know the evolution of mobility patterns;
- COPERT;
- Arduino/autonomous car.

Evaluation: on a week basis

Survey	Same weight
COPERTV	
Arduino car	
problems	
Exam/final assignement	30 %

471178 Mobilidade Sustentável 1º Semestre 1ª Época **21-01-2019** Seg
16:30:00 19:30:00 03:00:00 **6.2.49 | 6.2.50** miEEA

471178 Mobilidade Sustentável 1º Semestre 2ª Época **08-02-2019** Sex
09:00:00 12:00:00 03:00:00 **6.2.49 | 6.2.50** miEEA

471178 Mobilidade Sustentável 1º Semestre É. Especial **22-07-2019** Seg
09:00:00 12:00:00 03:00:00 3.1.07 miEEA

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 scenarios and impacts on energy and emissions;**
- ✓ **Compare different transport system in a life cycle perspective;**
- ✓ **Estimate carbon footprints.**

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 Environmment 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.

Portugal Solar Challenge



16 de Setembro
Marginal sem carros

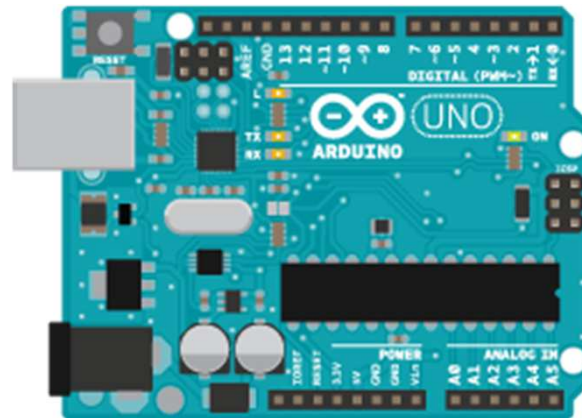
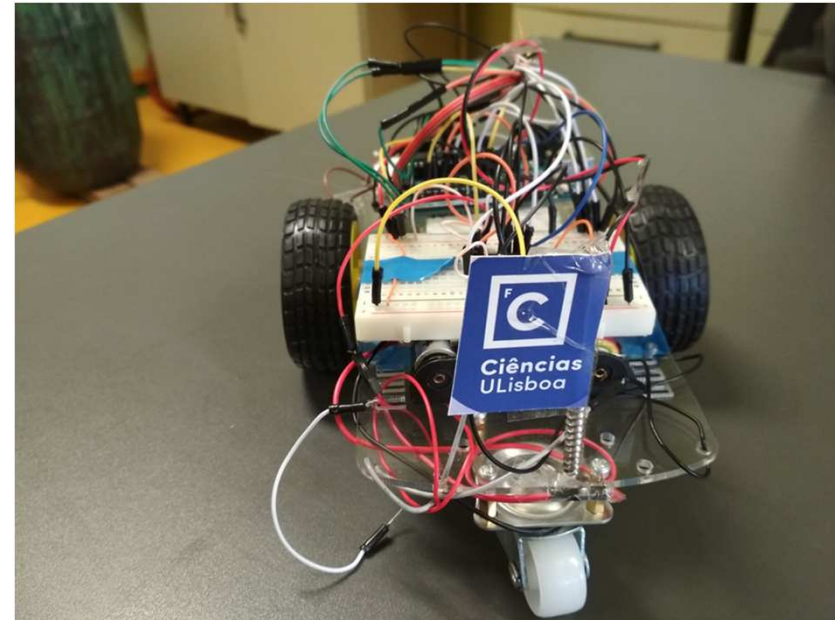


Council **Directive 96/62/EC** of 27 September 1996 on ambient air quality assessment and management

2001 dia europeu sem carros

16 a 22 de setembro semana Europeia da mobilidade

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



Catamarã “Energy Observer” <http://www.energy-observer.org/>



6 ANOS - 50 PAÍSES - 101 ESCALAS

2017 Volta a França
2018 O Mediterrâneo
2019 Norte da Europa
2020 Américas
2021 Ásia - Oceânia
2022 Ásia - Médio-Oriente



Exposição Energy Observer Village

De 21 a 30 de setembro, entre as 10h e as 20h

Doca da Marinha, frente ao Campo das Cebolas

Entrada livre (sem necessidade de marcação).
Terá informação sobre o barco e a expedição e
conteúdo interativo, nomeadamente
experiência de visita ao barco através de
realidade virtual.

Catamarã “Energy Observer” <http://www.energy-observer.org/>



7 Março

Portugal Solar Challenge



8 Março

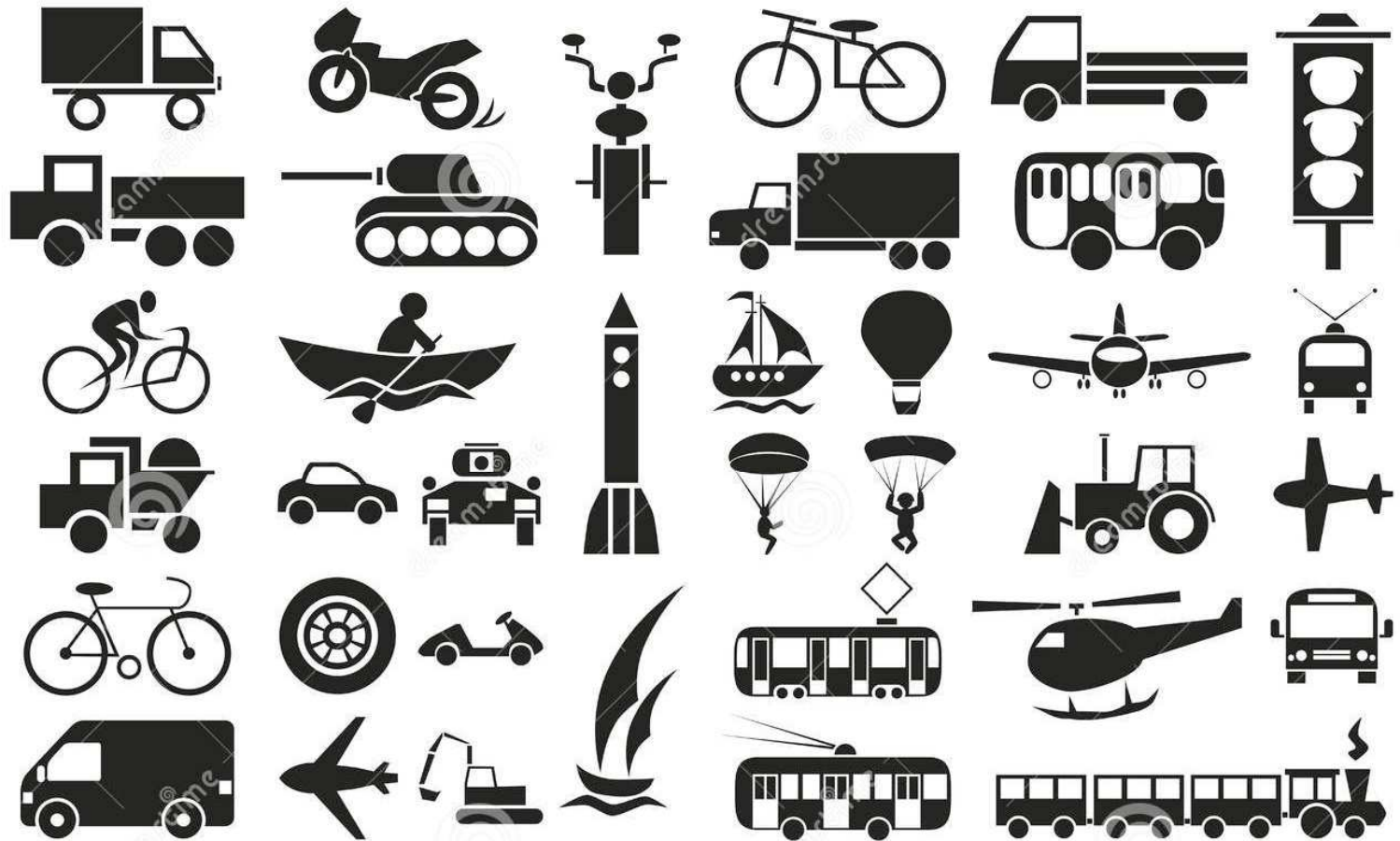
Inscrições através: [Formulário](#)



9, 10 e 11 Março

Inscrições através:
oficinaenergias@fc.ul.pt





Download from
Dreamstime.com

This watermarked comp image is for previewing purposes only.

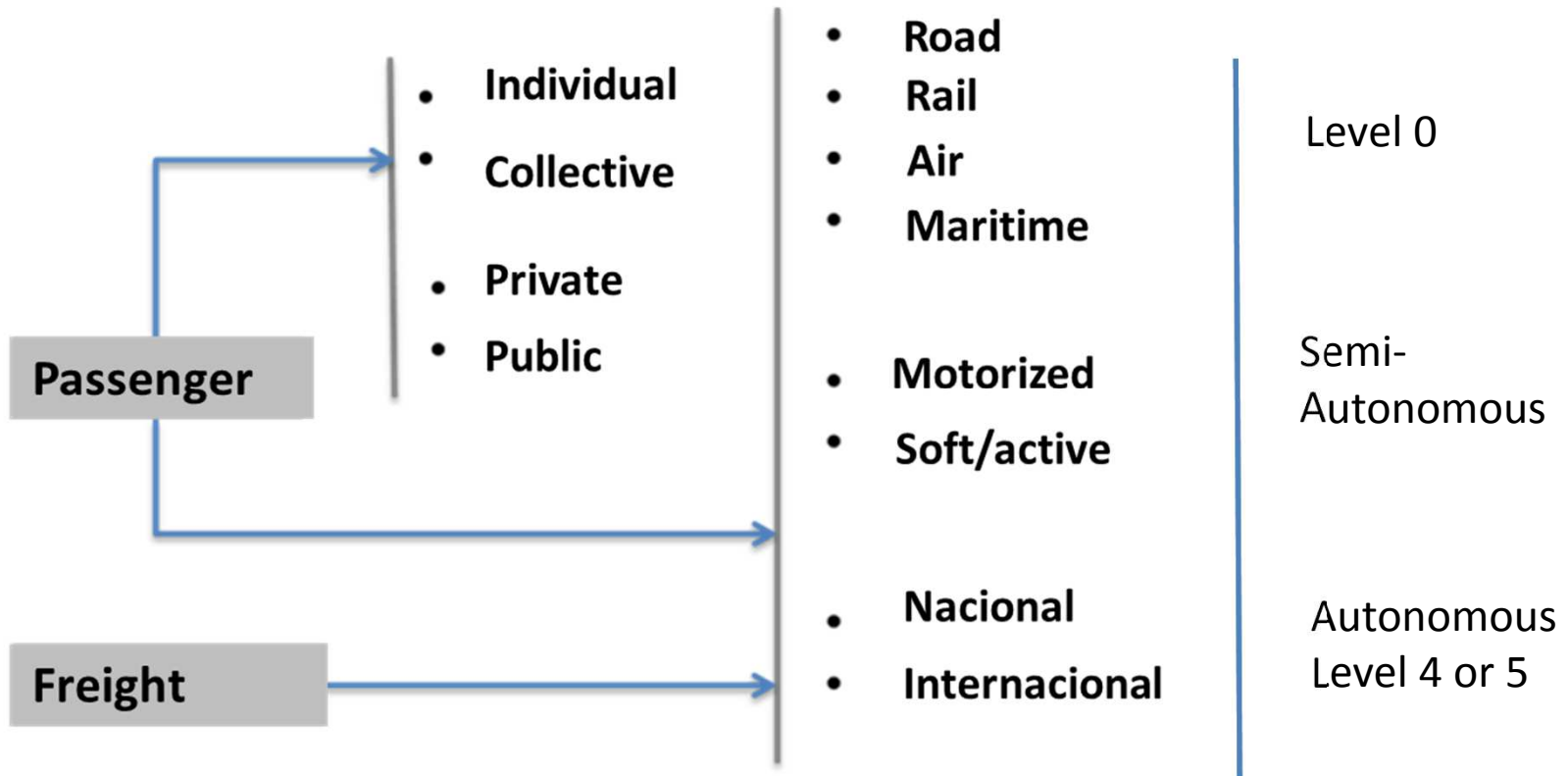
ID 53703370

@ Olga Botina | Dreamstime.com

- Passageiros e mercadorias motorizados



Classification....



Soft modes (modos suaves ou activos)

- Passageiros e mercadorias suaves





e.g. O táxi é transporte individual público de passageiros rodoviário motorizado

Uber transporte individual público de passageiros rodoviário motorizado



e.g. O autocarro é transporte colectivo de passageiros, publico, rodoviário, motorizado



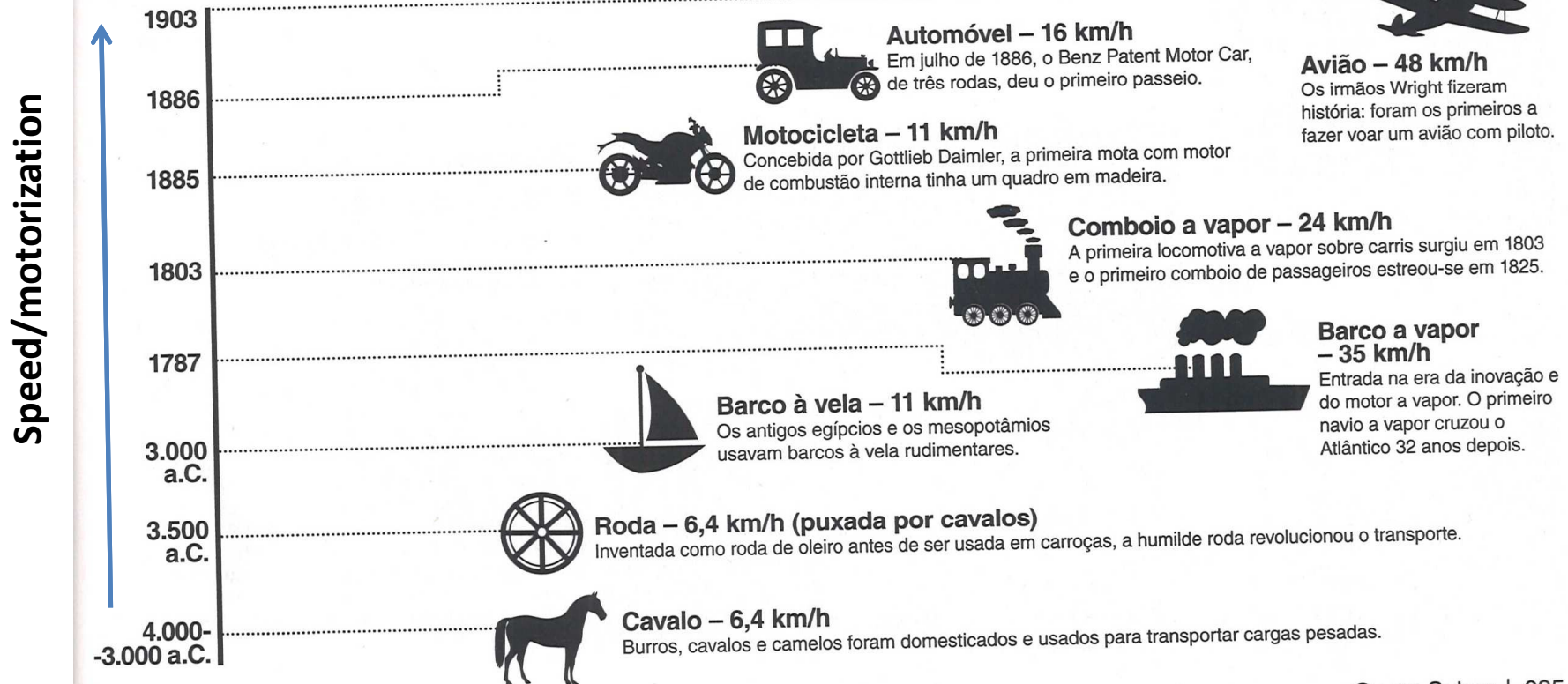
e.g. O *car-sharing* é transporte individual de passageiros publico, rodoviário motorizado



e.g. O *bike-sharing* é transporte individual de passageiros publico, rodoviário (motorizado no caso das elétricas)

Viajar através do tempo

Da carroça ao automóvel, como nos deslocámos de A para B ao longo da história.



WWW.QUEROSABER.SAPO.PT

Quero Saber | 085

New York on the 1800's



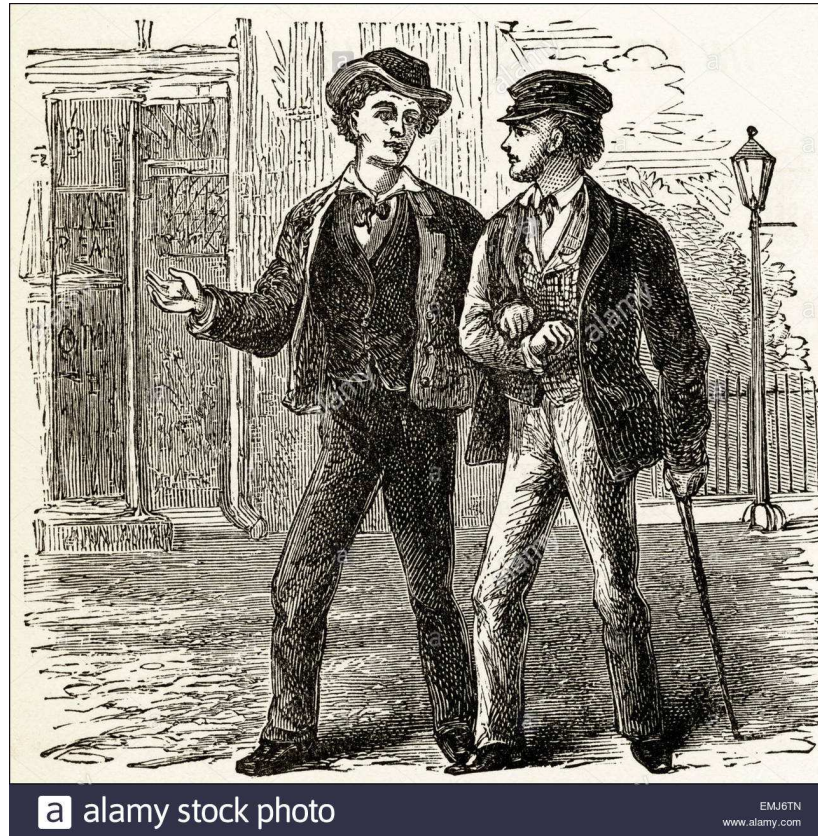
Lisbon on the 1800's, CARRIS carriage



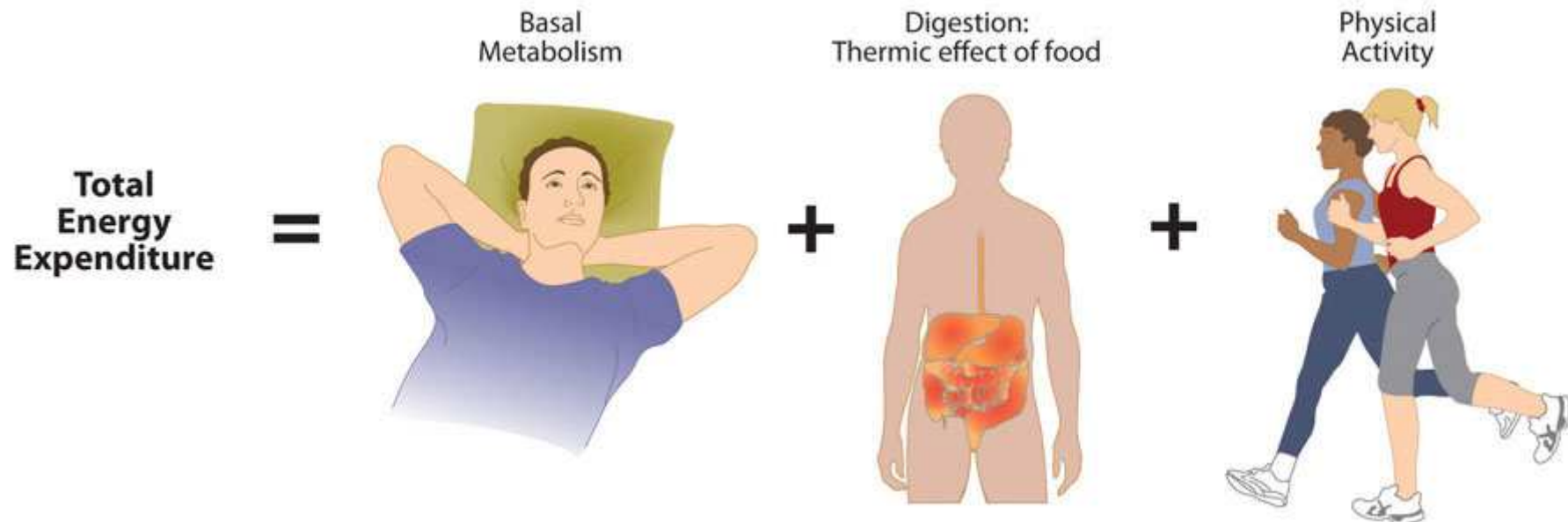
Lisbon Av. 24 Julho 1912, CARRIS electric tram

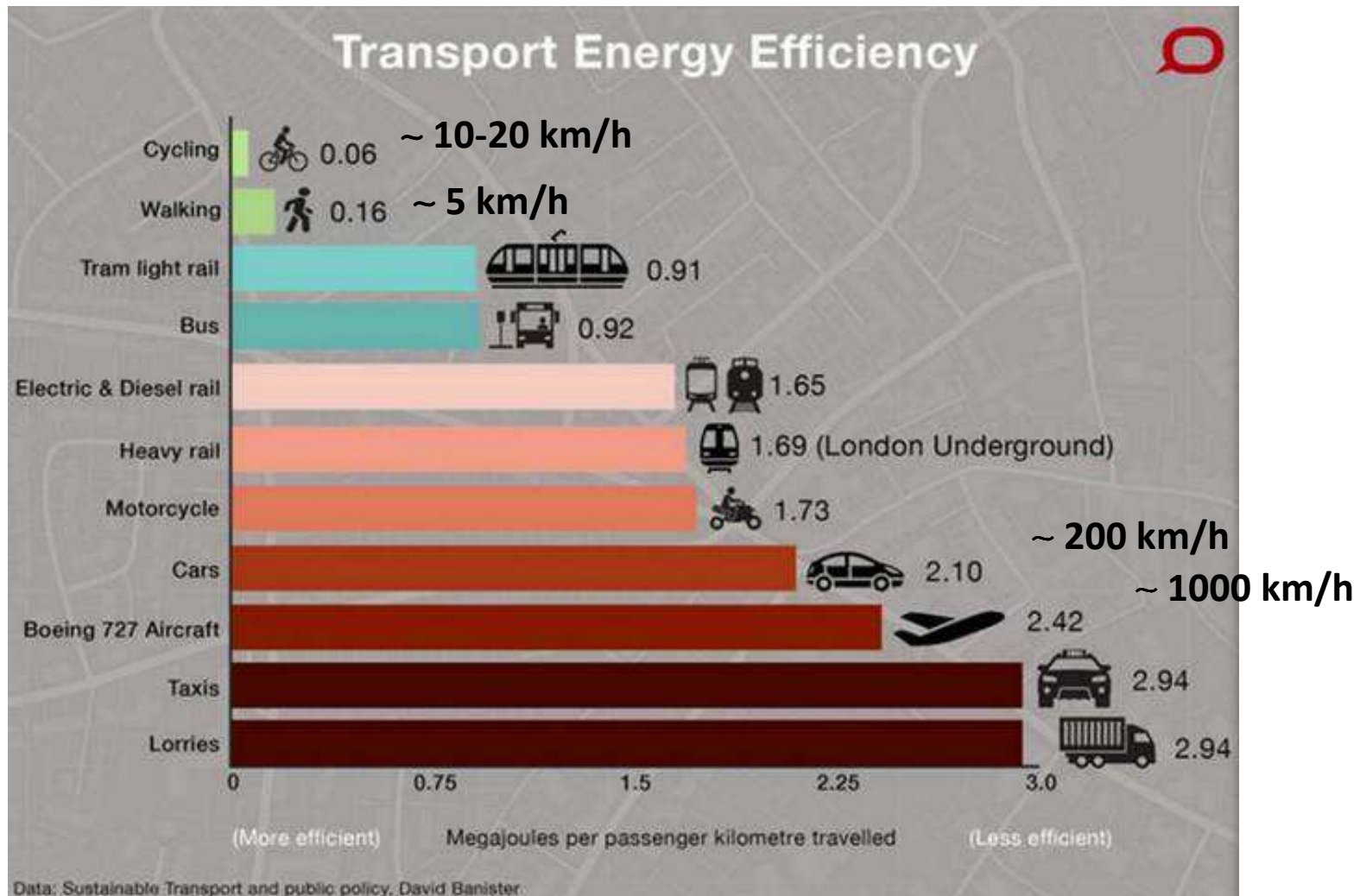


Walk....always....Energy????



Walk....always....Energy????









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

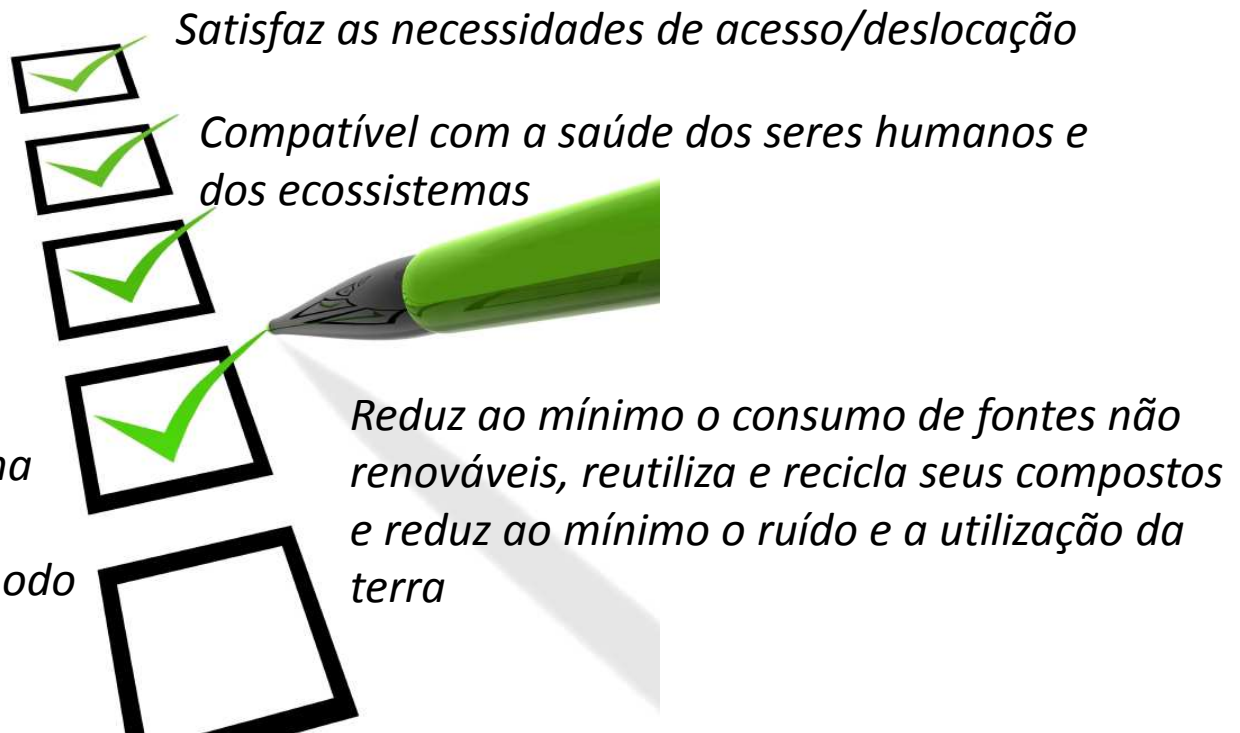
“a more sustainable transportation system” as “one which provides affordable access to freight and passenger service and does so in an environmentally sound and equitable manner”

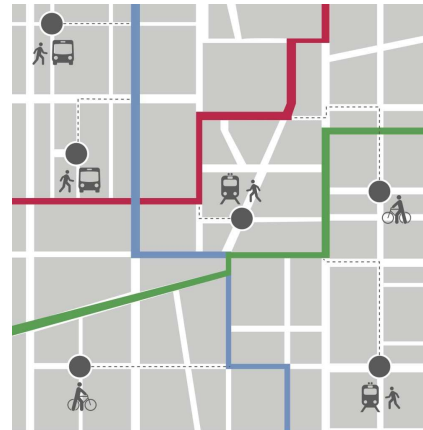
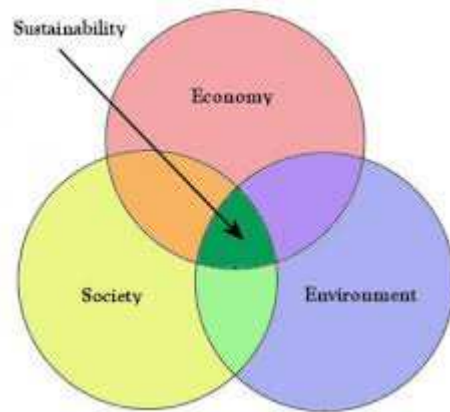
Black, 2010, from “Department
transportation Canada, 2003”

O que é a mobilidade sustentável?



Tem custos aceitáveis, funciona eficientemente, oferece a possibilidade de escolha do modo de transporte e apoia uma economia dinâmica e o desenvolvimento regional





✓ **Planning**
✓ **Mobility management**

7 INDICATORS

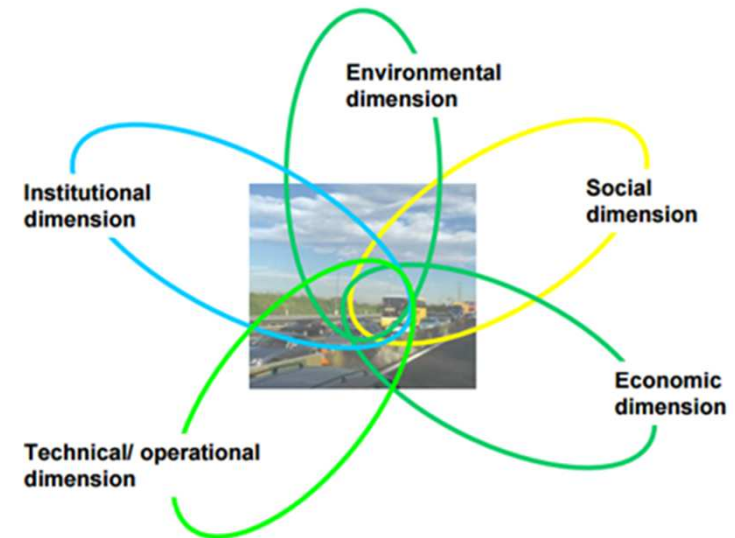
- A – Transportes Públicos
- B – Mobilidade Pedonal e Acessibilidade
- C – Mobilidade Ciclável
- D – Planos e Projetos
- E – Acalmia de Tráfego
- F – Sensibilização



APA, 14 de Fevereiro de 2012



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



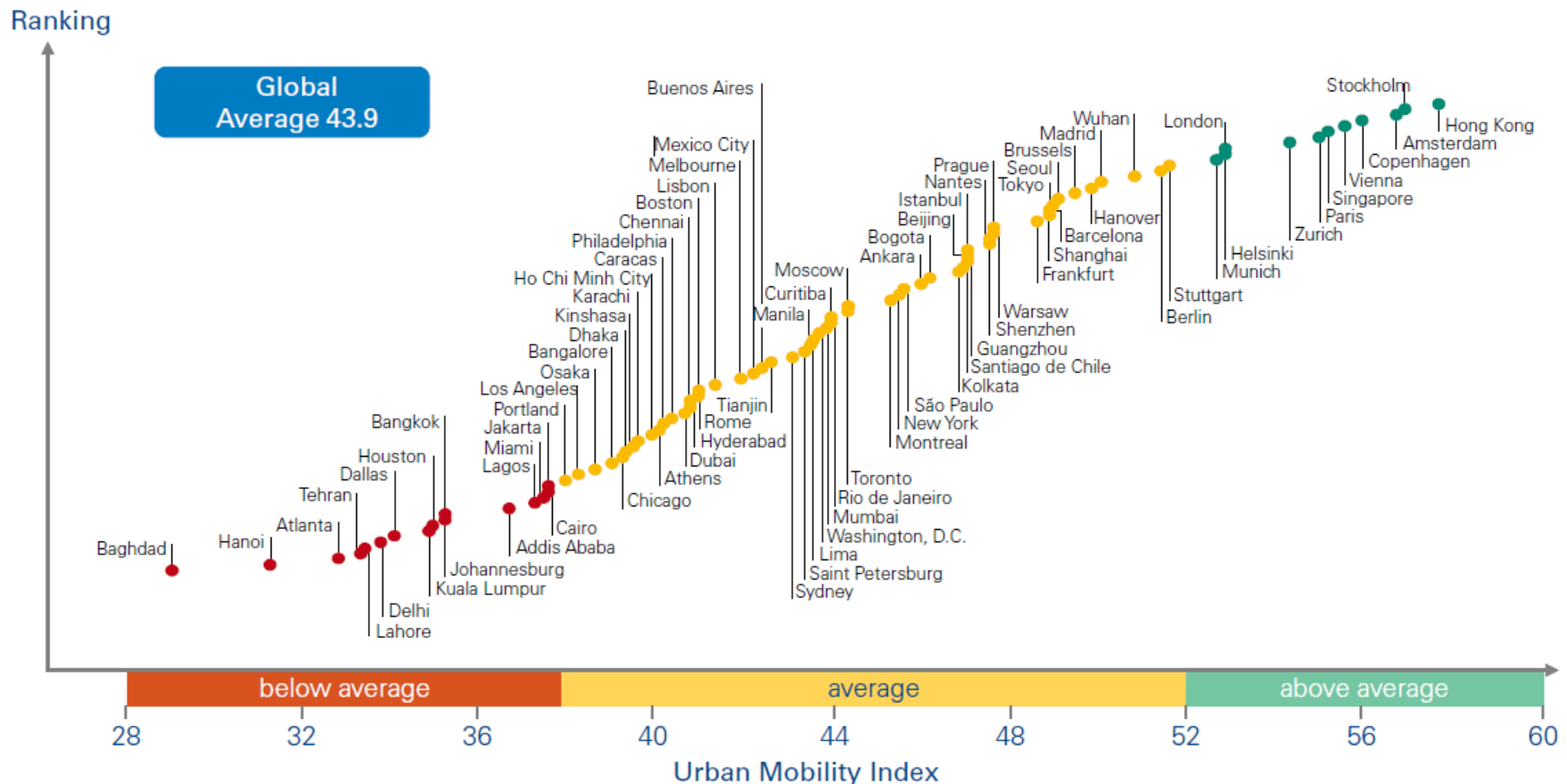
55 Indicators– Joint Research Centre





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

19 INDICATORS



What is sustainable mobility?

Figure 8: Top 11 cities with above average mobility score

Maturity indicators														Performance indicators						OVERALL SCORE
	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/this 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]	
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



World Business Council for Sustainable Development

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

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

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)

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

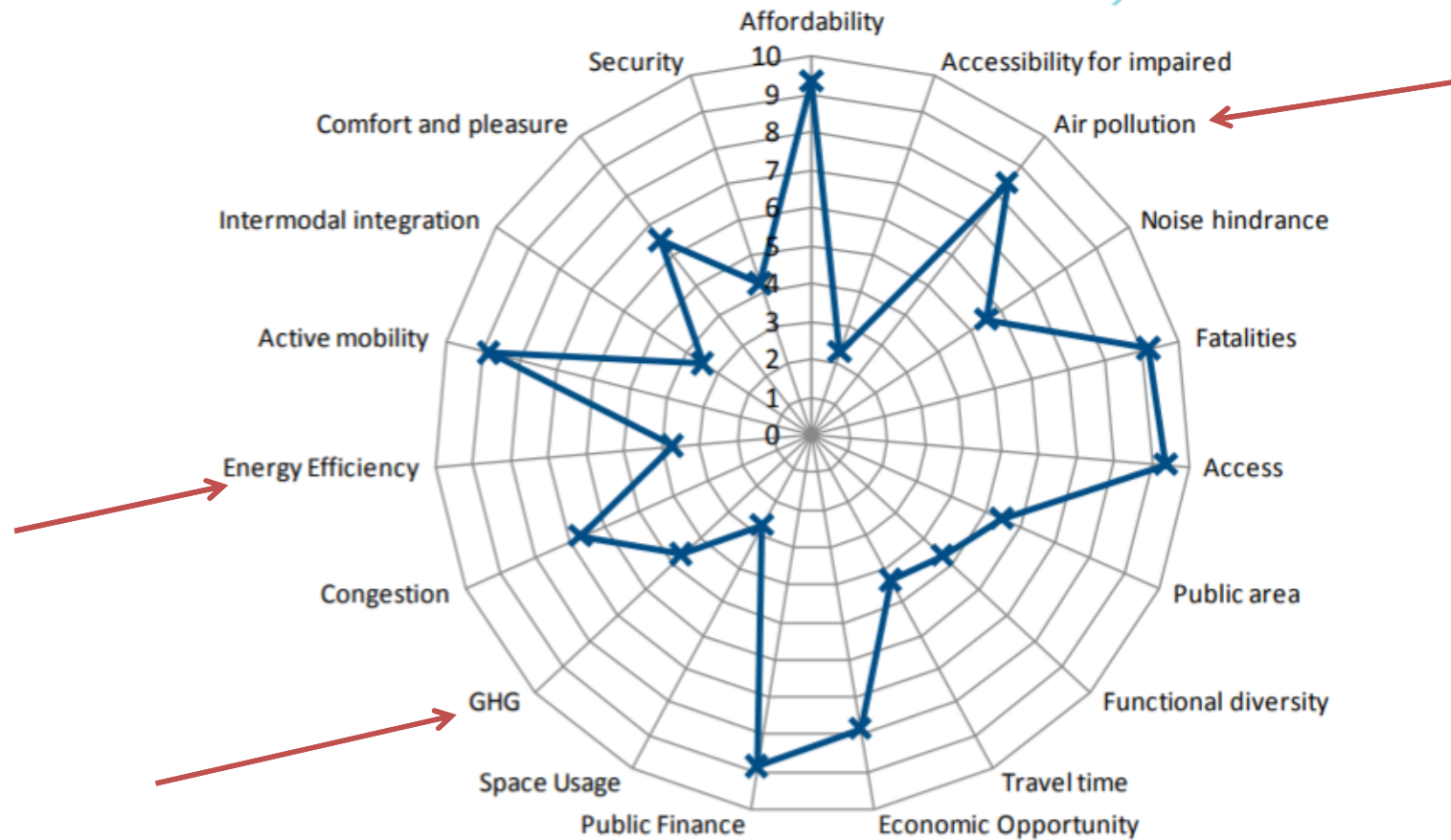
Table 1: Overview of the 19 Sustainable Urban Mobility Indicators indicating the dimensions of the sustainability of the mobility system. Source: Oran Consulting for WBCSD SMP2.0, 2014

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

19 INDICATORS



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 protection	Reduce global warming emissions Mitigate climate change impacts	Per capita emissions of global air pollutants (CO₂, CFCs, CH₄, 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. Least-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.

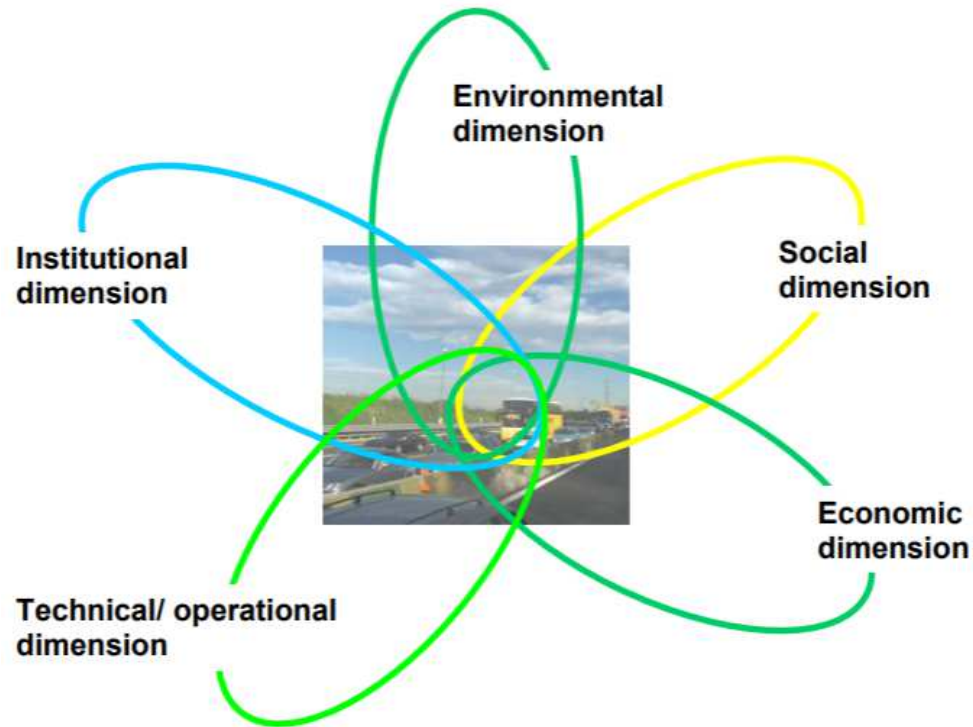
This table summarizes sustainability goals, objectives and performance indicators.



DIMENSIONS

VS

INDICATORS



EUR 23041 EN/2 - 2009

5 dimensions- 55 Indicators



55 Indicators– Joint Research Centre

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

DIMENSION	THEME	RELATED INDICATORS
ECONOMIC	<i>Transport Demand and Intensity</i>	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)
	<i>Transport Costs and Prices</i>	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)
		17. Road quality - paved roads, fair/ good condition
	<i>Infrastructure</i>	18. Total length of roads in km by mode

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



		19. Density of infrastructure (km·km ²)
SOCIAL	<i>Accessibility and Mobility</i>	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
	<i>Risk and Safety</i>	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)
	<i>Health Impacts</i>	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
	<i>Affordability</i>	29. Private car ownership
		30. Affordability (portion of households income devoted to transport)
	<i>Employment</i>	31. Contribution of transport sector (by mode) to employment growth



ENVIRONMENTAL	<i>Transport Emissions</i>	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 ₂ O emissions (per capita)
		39. CH ₄ emissions (per capita)
	<i>Energy Efficiency</i>	40. Energy consumption by transport mode (tonne-oil equivalent per vehicle km)
		41. Fuel consumption (vehicles-km by mode)
	<i>Impacts on Environmental Resources</i>	42. Habitat and ecosystem disruption
		43. Land take by transport infrastructure mode
	<i>Environmental Risks and Damages</i>	44. Polluting accidents (land, air, water)
		45. Hazardous materials transported by mode
	<i>Renewables</i>	46. Use of renewable energy sources (numbers of alternative-fuelled vehicles) - use of biofuels
TECHNICAL and OPERATIONAL	<i>Occupancy of Transportation</i>	47. Occupancy rate of passenger vehicles
		48. Load factors for freight transport (LDV, HDV)
	<i>Technology Status</i>	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	<i>Measures to Improve Transport Sustainability</i>	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
	<i>Institutional Development</i>	55. Uptake of strategic environmental assessment in the transport sector

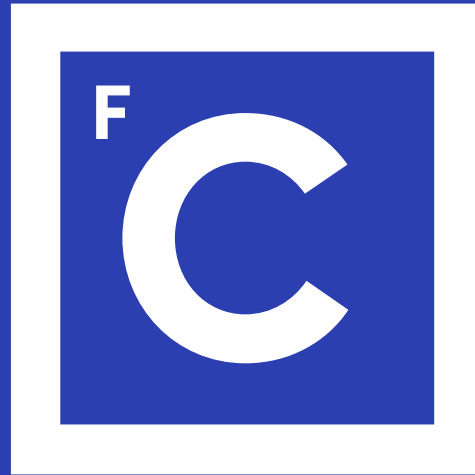


ENVIRONMENTAL	<i>Transport Emissions</i>	32. NOx emissions (per capita)
		33. VOCs emissions (per capita)
		34. PM ₁₀ and PM _{2.5} emissions (per capita)
		35. SOx emissions (per capita)
		36. O ₃ concentration (per capita)
		37. CO ₂ emissions (per capita)
		38. N ₂ O emissions (per capita)
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		45. Hazardous materials transported by mode
	<i>Renewables</i>	46. Use of renewable energy sources (numbers of alternative-fuelled vehicles) - use of biofuels

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

The image consists of a large blue square. Inside this square is a white square, which is further enclosed by a smaller blue square. The word "Obrigado" is written in white, bold, sans-serif font in the center of the innermost blue square.

Obrigado



Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa