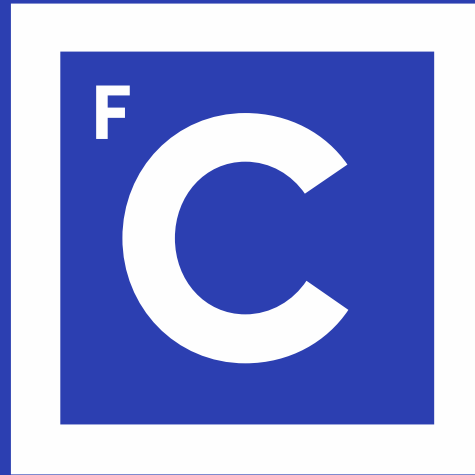




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DISCIPLINA MIEA 2018

move ► green



Mobilidade Sustentável

Home  Work/ University

on a regular basis

Commuting by motorized or soft modes

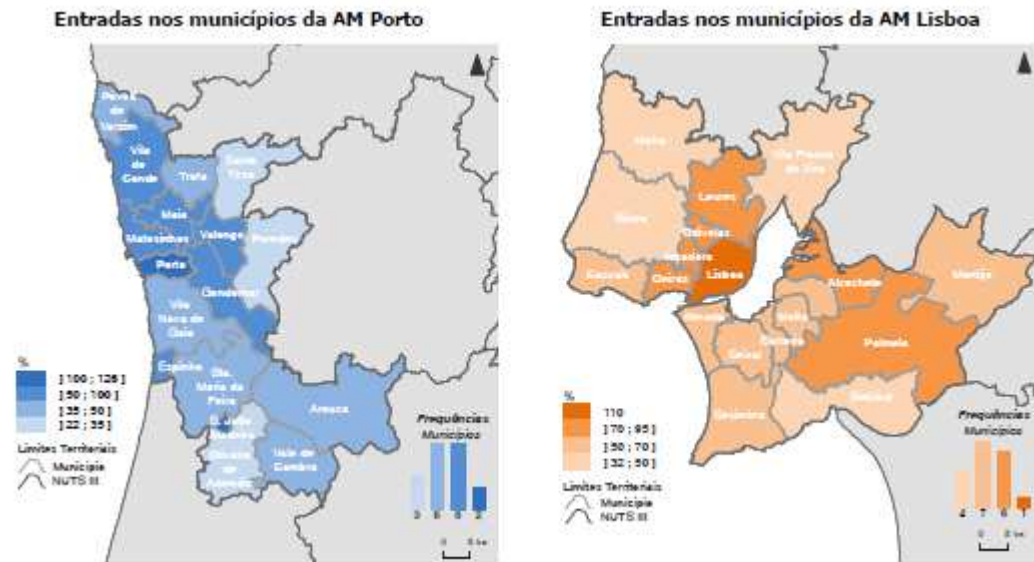


Emissions

Energy



Lisbon versus Porto (metropolitan areas)



sustainable mobility????

Indicator	Weight	Definition
CO ₂	5	emissions from commuting in kg/capita/year (non-biogenic)
PM10	10	Annual hourly arithmetic average
NO _x	10	Annual hourly arithmetic average
O ₃	10	Annual hourly arithmetic average
Energy	5	% fossil final energy consumption

Minimum and maximum values of indicator scale

PM10	150 -10 (µg/m ³)
CO ₂	7.5- 0 (ton/capita/year)
NO _x	200- 0 (µg/m ³)
O ₃	240-0 (µg/m ³)
Energy	100-0 (%)



Capita

Área Metropolitana do Porto (AMP) 1.60 Million people

Área Metropolitana de Lisboa (AML) 2.57 Million people

Exercise. Recent mobility survey 2017 Porto and Lisbon. Calculate the sustainable mobility index for each city. What can you say?

Impact of people travel?

Quadro 9

Tempo e distância por deslocação, segundo o principal meio de transporte das deslocações

AM Lisboa

km per trip



		Duração média (minutos)	Distância média (km)
AM Lisboa		24.3	10.3
car	Automóvel - condutor	21.7	12.7
	Automóvel - passageiro	20.8	13.3
motorbike	Motociclo/ciclomotor	18.0	11.7
bus	Autocarro (transporte público)	45.7	12.1
train	Comboio	53.4	19.1
subway	Metropolitano	39.7	8.5
boat	Barco	58.1	19.5
	Táxi	19.6	6.4
van	Transporte escolar / empresa	32.6	17.2
walk	A pé	17.0	1.5
bike	Bicicleta	36.2	8.8
	Outro/desconhecido	31.7	24.2

Nota: Exclui as deslocações internacionais

Recent mobility survey 2017 Porto and Lisbon

Impact of people travel?

Quadro 6

[Voltar ao Índice](#)

Deslocações por tipo de dia e meio de transporte principal da deslocação

AM Lisboa

Unidade:10³

		Deslocações		
		Total semanal	Dias úteis	SDF a)
AM Lisboa		37,697.1	27,439.7	10,257.4
Transporte individual		22,542.4	15,715.5	6,826.9
car	Automóvel - condutor	17,326.3	12,334.4	4,992.0
	Automóvel - passageiro	4,884.7	3,110.2	1,774.5
motorbike	Motociclo/ciclomotor	331.3	270.9	60.4
Transporte público ou coletivo		5,939.5	5,056.6	882.9
<i>Dos quais:</i>				
bus	Autocarro	2,945.9	2,476.0	469.9
train	Comboio	1,215.7	1,032.0	183.7
subway	Metropolitano	1,167.8	1,014.6	153.2
Walk and bike	Modos suaves (a pé e bicicleta)	8,857.7	6,404.3	2,453.4
Outro/desconhecido		357.4	263.4	94.1

a) SDF - Sábados, domingos e Feriados

Number trips
per
mode~people
per mode

Quadro 9

[Voltar ao Índice](#)

Tempo e distância por deslocação, segundo o principal meio de transporte das deslocações

km per trip

AM Porto

	Duração média (minutos)	Distância média (km)
AM Porto	21.8	10.1
Automóvel - condutor	18.0	11.4
Automóvel - passageiro	17.6	11.4
Motociclo/ciclomotor	13.5	7.4
Autocarro (transporte público)	40.6	9.8
Comboio	57.6	31.0
Metropolitano	37.6	9.4
Barco	12.5	0.7
Táxi	19.4	8.7
Transporte escolar / empresa	32.8	23.5
A pé	24.5	2.3
Bicicleta	35.9	9.5
Outro/desconhecido	38.2	34.8

Nota: Exclui as deslocações internacionais

Quadro 6

[Voltar ao Índice](#)

Deslocações por tipo de dia e meio de transporte principal da deslocação

AM Porto

Unidade: 10³

	Deslocações		
	Total semanal	Dias úteis	SDF a)
AM Porto	23,987.4	17,098.6	6,888.8
Transporte individual	16,546.7	11,372.4	5,174.3
Automóvel - condutor	12,162.1	8,454.0	3,708.1
Automóvel - passageiro	4,061.4	2,687.8	1,373.7
Motociclo/ciclomotor	323.1	230.6	92.5
Transporte público ou coletivo	2,670.4	2,282.1	388.3
<i>Dos quais:</i>			
Autocarro	1,628.5	1,384.7	243.9
Comboio	190.2	168.6	21.6
Metropolitano	473.9	390.6	83.3
Modos suaves (a pé e bicicleta)	4,536.9	3,268.1	1,268.7
Outro/desconhecido	291.1	57.5	233.5

a) SDF - Sábados, domingos e Feriados

Number trips Per mode

BUS



→ Data MJ/pkm from sustainability report 1.6 MJ/pkm

CAR



→ Most sold vehicle, VCA info

0-100 km/h 14.5 s
European test cycle l/100km 5.6
1059 kg (2 MJ/km)

TRAIN



→ Data MJ/pkm from sustainability report 0.3 MJ/pkm

SUBWAY



→ Data 16.9 MJ/pkm from sustainability report

BUS



→ Data MJ/pkm from sustainability report 0.7 MJ/pkm

CAR



→ Most sold vehicle, VCA info

0-100 km/h	14.5 s	
European test cycle l/100km		5.6
1059 kg (2 MJ/km)		

TRAIN



Data MJ/pkm from sustainability report 0.3 MJ/pkm

SUBWAY



Data 0.47 MJ/pkm from sustainability report (0.131 kWh/pkm)

First estimation (high uncertainty) emissions proportional to fuel consumption

Table 3.15: Tier 1 — Typical fuel consumption figures, per km, by category of vehicle

Vehicle category (j)	Fuel	Typical fuel consumption (g/km)
Passenger cars	Petrol	70
	Diesel	60
	LPG	57.5
	E85	86.5
	CNG	62.6
LCV	Petrol	100
	Diesel	80
HDV	Diesel	240
	CNG (buses)	500
Two-wheel vehicles	Petrol	35

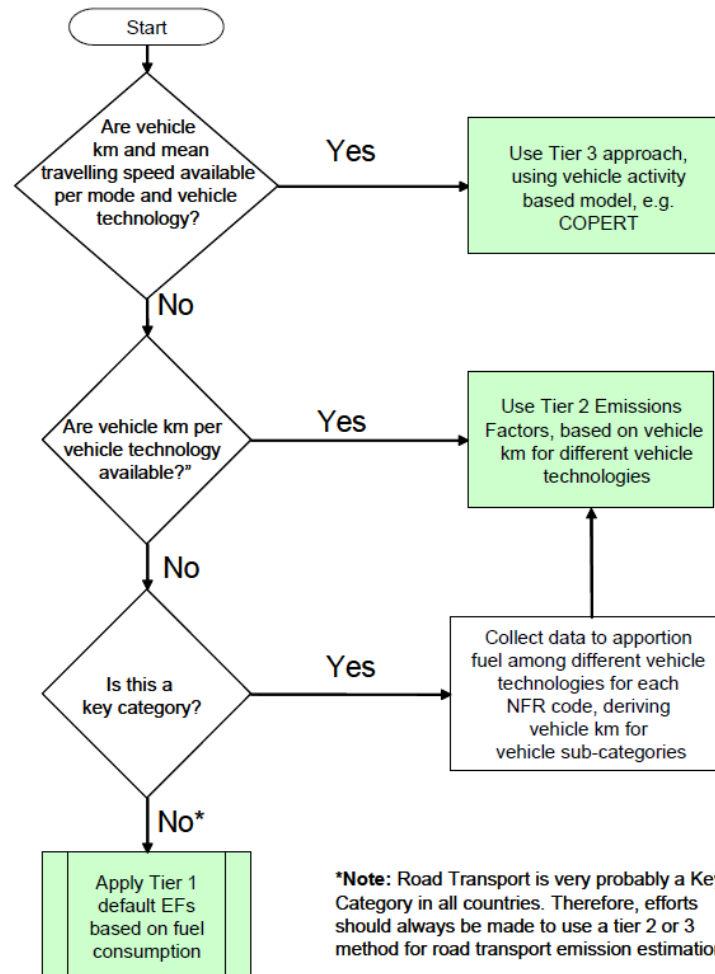
$$60\text{g/km} \times 42.5\text{MJ/kg} \times 10^{-3}\text{kg/g} = 2.6\text{ MJ/km}$$

$$10.2\text{ MJ/km}$$

$$35\text{g/km} \times 44\text{MJ/kg} \times 10^{-3}\text{kg/g} = 1.54\text{ MJ/km}$$

Passenger cars, light commercial trucks, heavy-duty vehicles including buses and motor cycles

Figure 3-1 Decision tree for exhaust emissions from road transport



Do you need this information for the indicator?????

Surveys, energy & emissions

Or this from the European standard test cycle ?????

August 2017



Vehicle Certification Agency

Manufa	Model	Description	Trans	Engine	Fuel	Metric	Metric	Metric	CO2	Emissions	Emissions	THC + NOx	Particulates
cturer			missio	Capacit	Type	Urban	Extra-	Combin	g/k	CO	NOx	Emissions	[No.]
RENAU			n	y	Dies	(Cold)	Urban	ed	m	[mg/km]	[mg/km]	[mg/km]	[mg/km]
LT	Clio Euro6, 2015	dCi 110 S/S	M6	1461	el	3.8	3.3	3.5	90	354	18	60	0.08
RENAU		Energy dCi 90			Dies								
LT	Clio Euro6, 2015	S/S	M5	1461	el	3.5	3.1	3.3	85	158	33	60	0.08
RENAU		Energy dCi 90			Dies								
LT	Clio Euro6, 2015	S/S ECO	M5	1461	el	3.3	3.1	3.2	82	158	33	60	0.08
RENAU	Clio Sport Tourer				Dies								
LT	Euro6, 2015	dCi 90 S/S	M5	1461	el	3.5	3.1	3.3	85	158	33	60	0.08
RENAU	Clio Sport Tourer	Energy dCi 90			Dies								
LT	Euro6, 2015	S/S ECO	M5	1461	el	3.4	3.1	3.2	84	158	33	60	0.08
RENAUL		Energy TCe 90											
T	Clio Euro6, 2015	S/S	M5	898	Petrol	5.7	4.1	4.7	105	327	28		
RENAUL	Clio Sport Tourer	Energy TCe 90											
T	Euro6, 2015	S/S	M5	898	Petrol	5.7	4	4.6	104	327	28		

Worldwide Harmonized Light Vehicles Test Cycle (WLTC)

AQS – QUALAR data (downloads section)



Maia	D.Manuel II-Vermoim	Urban	Traffic
Matosinhos	João Gomes Laranjo-S.Hora	Urban	Traffic
Porto	Francisco Sá Carneiro-Campanha	Urban	Traffic
Lisboa	Entrecampos	Urban	Traffic
Lisboa	Avenida da Liberdade	Urban	Traffic
Lisboa	Santa Cruz de Benfica	Urban	Traffic
Odivelas	Odivelas-Ramada	Urban	Traffic

AQS – QUALAR data (downloads section)

Lisboa Entrecampos Urban Traffic

Data (Hora UTC)	Dióxido de Enxofre µg/m3	Partículas < 10 µm µg/m3	Ozono µg/m3	Dióxido de Azoto µg/m3	Óxidos de Azoto µg/m3	Monóxido de Carbono mg/m3	Benzeno µg/m3	Monóxido de Azoto µg/m3	Partículas < 2.5 µm µg/m3
01/10/2017 00:00	0,000		69,060	6,640	7,500	0,154	0,2	0,570	
01/10/2017 01:00	0,070		66,450	6,910	8,540	0,160	0,2	1,060	
01/10/2017 02:00	0,180		64,950	5,540	6,750	0,160	0,2	0,790	
01/10/2017 03:00	0,730		61,160	7,540	10,680	0,148	0,1	2,040	
01/10/2017 04:00	0,990		60,570	4,790	5,920	0,142	0,1	0,740	
01/10/2017 05:00	1,330		55,530	8,690	13,250	0,151	0,1	2,970	
01/10/2017 06:00	2,270		52,110	10,800	12,660	0,154	0,1	1,210	
01/10/2017 07:00	2,160		48,110	13,360	16,650	0,168	0,1	2,140	
01/10/2017 08:00	2,310		45,740	15,830	23,370	0,183	0,2	4,920	
01/10/2017 09:00	2,720		52,910	13,050	20,060	0,189	0,2	4,570	
01/10/2017 10:00	3,550		56,550	16,280	24,880	0,206	0,2	5,610	
01/10/2017 11:00	3,260		67,230	14,320	20,890	0,203	0,4	4,280	
01/10/2017 12:00	0,390		68,670	30,410	54,460	0,270	0,5	15,690	
01/10/2017 13:00	1,190		82,660	22,580	31,730	0,229	0,4	5,970	
01/10/2017 14:00	0,930		87,450	17,720	23,080	0,209	0,3	3,500	
01/10/2017 15:00	0,000		77,960	19,800	25,220	0,206	0,4	3,530	
01/10/2017 16:00	0,000		64,840	24,610	31,890	0,215	0,4	4,750	
01/10/2017 17:00	0,000		49,360	31,950	41,360	0,218	0,4	6,130	
01/10/2017 18:00	0,000		49,560	25,920	32,250	0,197	0,4	4,130	
01/10/2017 19:00	0,000		52,330	16,800	21,980	0,183	0,3	3,380	
01/10/2017 20:00	0,000		35,770	40,130	54,200	0,331	0,4	9,180	
01/10/2017 21:00	0,000		38,530	38,140	46,670	0,252	0,9	5,560	

AQS – QUALAR data (downloads section)

2017	µg/m3	PM10	O ₃	NOx
Lisboa	Entrecampos	32.7	44	40.9
Lisboa	Avenida da Liberdade	33.5	NA	60.4
Lisboa	Santa Cruz de Benfica	36.4	NA	38.2
Odivelas	Odivelas-Ramada	24.2	NA	26.8
Average		31.7	44	41.6

AQS – QUALAR data (downloads section)

2017	µg/m ³	PM10	O ₃	NO _x
Maia	D.Manuel II-Vermoim	14.7	48.1*	17.9
Matosinhos	João Gomes	20.7	42.8*	30.8
Laranjo-S.Hora				
Porto	Francisco Sá Carneiro-	19	39.6*	54
Campanha				
Average		18.1	43.5*	34.2

*nearest air quality monitoring station

AQS – QUALAR data (downloads section)



Maia	D.Manuel II-Vermoim	Urban	Traffic
Matosinhos	João Gomes Laranjo-S.Hora	Urban	Traffic
Porto	Francisco Sá Carneiro-Campanha	Urban	Traffic

PM10	O₃	NOx
18.1	43.5	34.2

Lisboa	Entrecampos	Urban	Traffic
Lisboa	Avenida da Liberdade	Urban	Traffic
Lisboa	Santa Cruz de Benfica	Urban	Traffic
Odivelas	Odivelas-Ramada	Urban	Traffic

PM10	O₃	NOx
31.7	44	41.6

CO2 emissions from combustion mass balance

LHV 42.4 MJ/kg Diesel $C_{12}H_{24}$ $\frac{12 \cdot 44}{12 \cdot 12 + 28} / 42.4 = 72.4 \text{ g/MJ}$

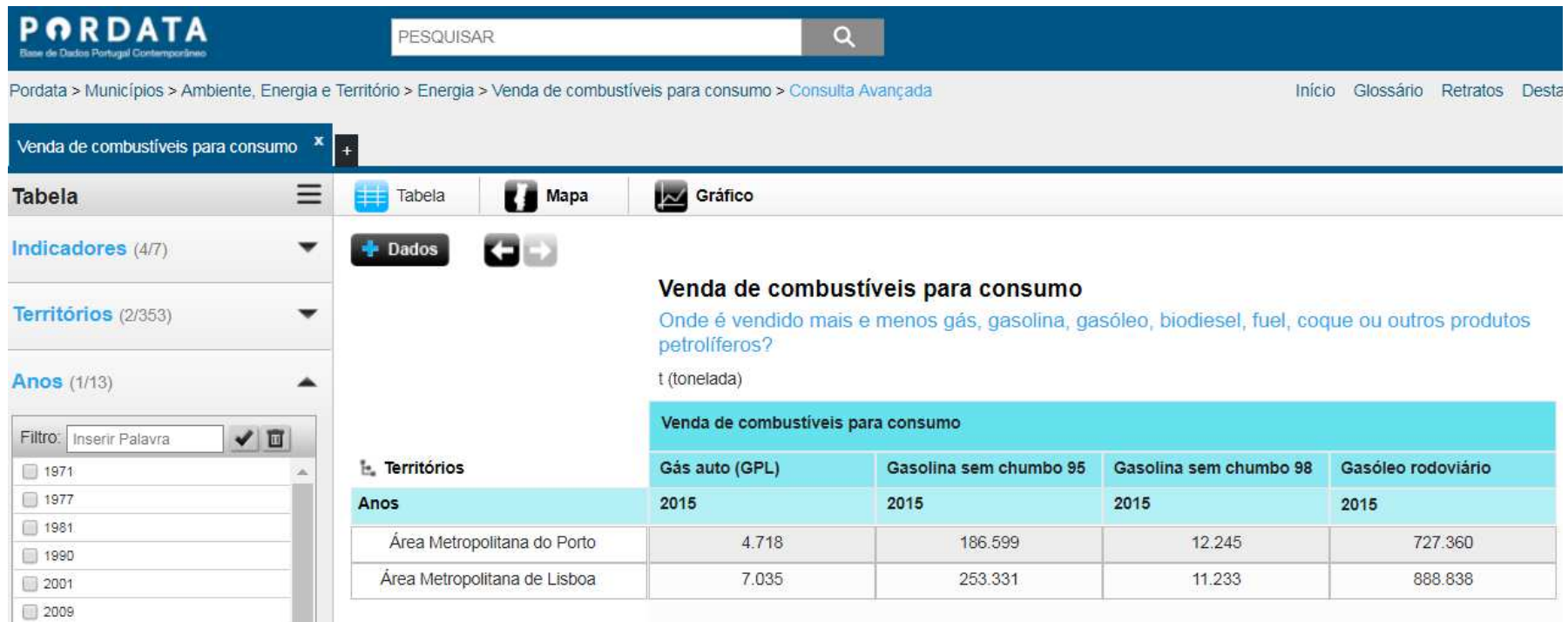
44 MJ/kg Gasoline C_8H_{18} $\frac{8 \cdot 44}{8 \cdot 12 + 18} / 44 = 70.2 \text{ g/MJ}$



	Density at STP (kg/m ³)	Ratio of HHV to LHV energy content	Net Calorific Value / LHV		Gross Calorific Value / HHV		Carbon Intensity (g CO ₂ -eq / MJ LHV)
			(MJ/L)	(MJ/kg)	(MJ/L)	(MJ/kg)	
Crude Oil	856 ± 24	1.052 ± 0.001	36.84 ± 1.05	43.05 ± 1.40	38.76 ± 1.10	45.30 ± 1.47	73.5 ± 2.6
Petrol / Gasoline	741 ± 4	1.063 ± 0.015	32.70 ± 0.44	44.15 ± 0.74	34.77 ± 0.47	46.94 ± 0.70	70.8 ± 4.4
Diesel	837 ± 8	1.063 ± 0.011	35.94 ± 0.45	42.91 ± 0.46	38.19 ± 0.47	45.60 ± 0.49	74.3 ± 2.3

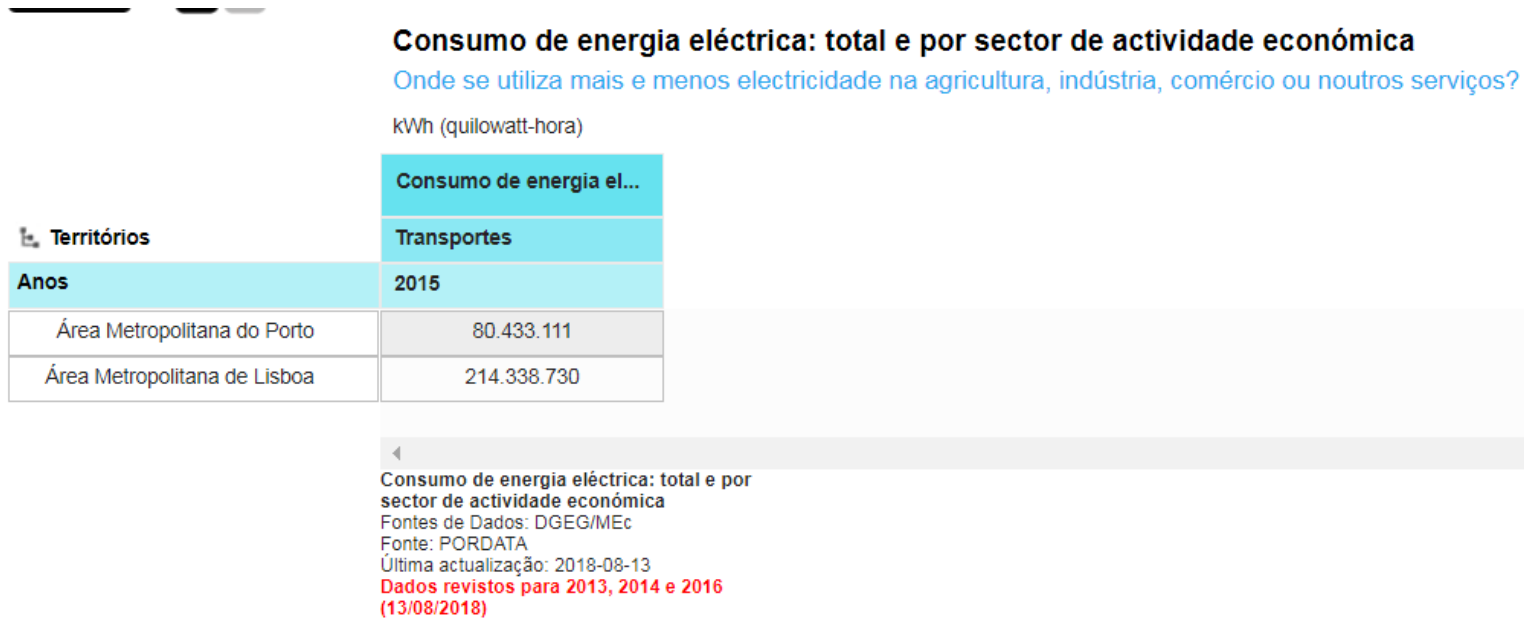
Control point Fuel sales

100% fossil fuel



Control point Fuel sales

60% Fossil



Comparing transport systems??



Sustainable mobility indicators

$$I_{\text{sust mob}} = I_{\text{CO}_2} + I_{\text{NO}_x} + I_{\text{O}_3} + I_{\text{PM}} + I_{\text{Energy}}$$

I_{CO_2}

I_{NO_x}

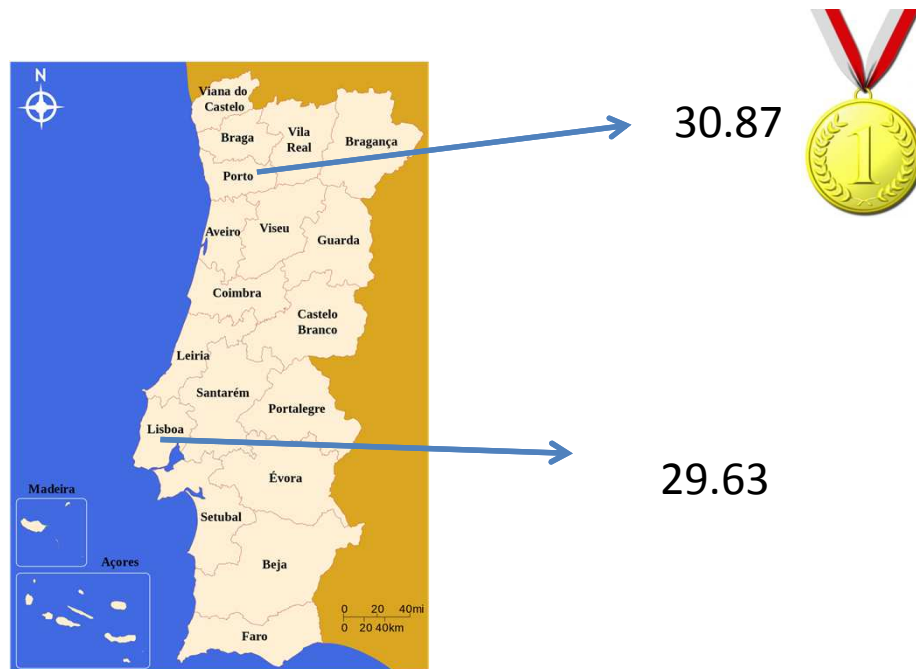
Link Excel (available Fénix)

I_{O_3}

I_{PM}

I_{Energy}

Comparing transport systems??

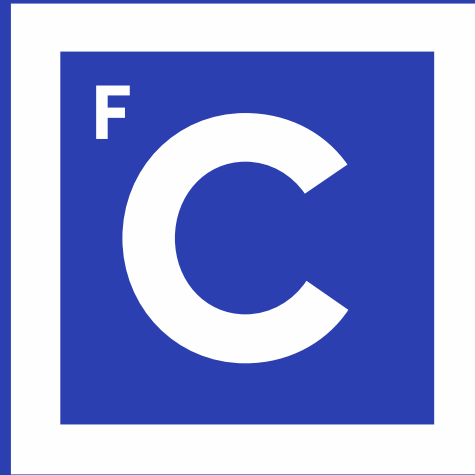


Porto more sustainable than Lisbon....but similar.....less PM10....better air quality..... higher fossil energy consumption

-
- Calculation of a sustainable mobility index for 2 case studies;
 - When use European Environmental Agency Tier1 /Tier2/Tier3 approach;
 - Fuel sales as a control point;
 - AQS-Air Quality Stations data usage;
 - Fossil versus renewable.

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



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