Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2019

Mobilidade Sustentável

Comparing transport systems??

Sustainable mobility indicators (7 to 55!)

Indicators of sustainable Mobility

11 Indicators/metrics

Environmental

DIMENSION

Emissions per year (per capita)

Human exposure/air quality related

NOx (NO and NO_2)
VOCs
CO
PM10
PM2.5
SOx
O_3

Ton or g/year Or g/pkm

Global warming related

CO_2
N_2O
CH_4

Energy consumption per year (per capita)

MJ or MJ/year Or MJ/pkm

Carla Silva camsilva@fc.ul.pt

Minimum energy and emissions

Home ⟷ **Work (or university)**

Commuting

Minimum energy and emissions

Emissions

Energy

History.....and...future

Walking….always….speed? Energy????Emissions???

The Revised Harris-Benedict Equation:

- for men, $P = \left(\frac{13.397m}{1\text{ kg}} + \frac{4.799h}{1\text{ cm}} - \frac{5.677a}{1\text{ year}} + 88.362 \right) \frac{\text{kcal}}{\text{day}}$
- for women, $P = \left(\frac{9.247m}{1\text{ kg}} + \frac{3.098h}{1\text{ cm}} - \frac{4.330a}{1\text{ year}} + 447.593 \right) \frac{\text{kcal}}{\text{day}}$

Basal energy

Harris JA, Benedict FG (1918). "A Biometric Study of Human Basal Metabolism". Proceedings of the National Academy of Sciences of the United States of America. 4 (12): 370–3.

A Biometric Study of Basal Metabolism in Man. J. Arthur Harris and Francis G. Benedict. Washington, DC: Carnegie Institution, 1919.

-55.0969 + (0.6309 x **HR**) + (0.1988 x **W**) + (0.2017 x **A**)

Activity energy **kJ/min**

-20.4022 + (0.4472 x **HR**) - (0.1263 x **W**) + (0.074 x **A**)

HR = Heart rate (in beats/minute)

W = Weight (in kilograms)

A = Age (in years)

Baseline Emissions?

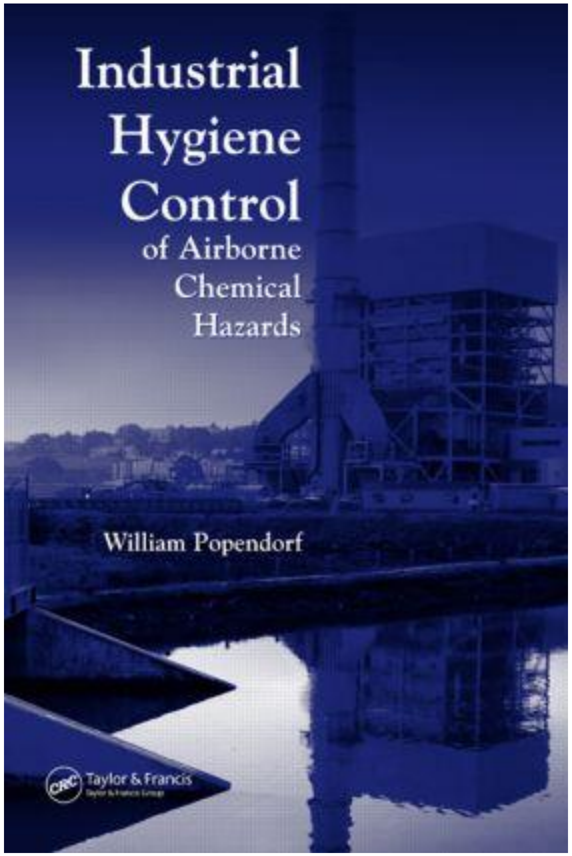
Metabolic Work Rate (Watts or J/s)

MWR = - 1967 + 8.58 HR + 25.1 HT + 4.50 A – 7.47 RHR + 67.8 G

Where,
HR is heart rate (bpm)
HT is height (in.)
A is age (yr),
RHR is resting heart rate (bpm)
G is gender (M=0, F=1).

@ Predictive Models for Estimating Metabolic Workload based on Heart Rate and Physical Characteristics

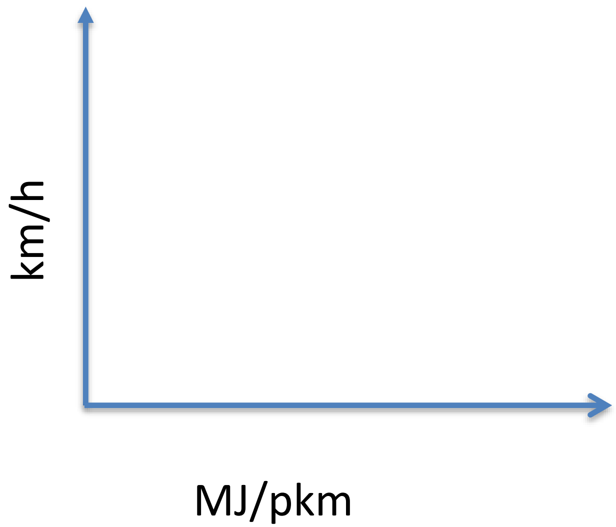
Biogenic CO_2

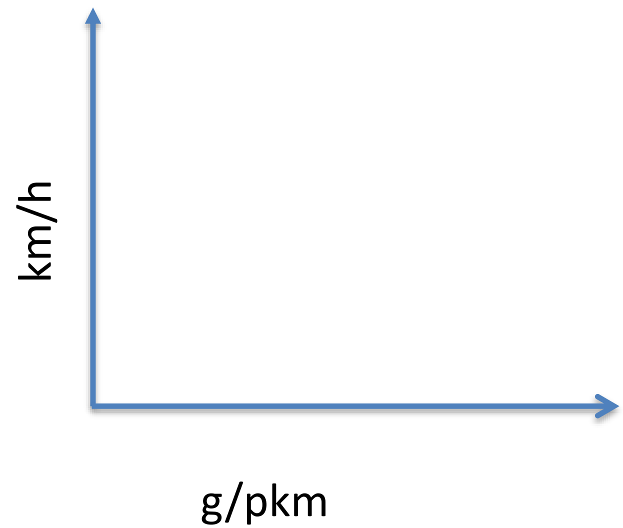


0.075 gCO_2/MJ

Estimate your energy for regular walking (at least 3 repetitions of the measurements), in MJ/pkm, and speed (km/h). What would be your graph?

Excel file by e-mail

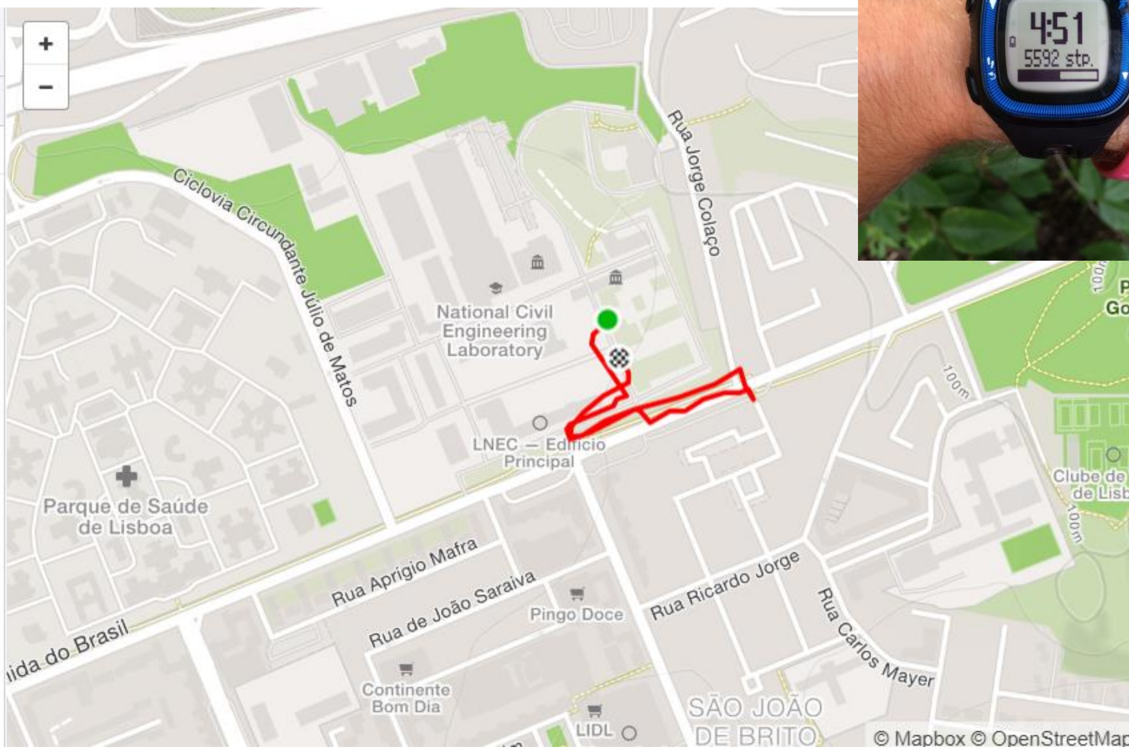




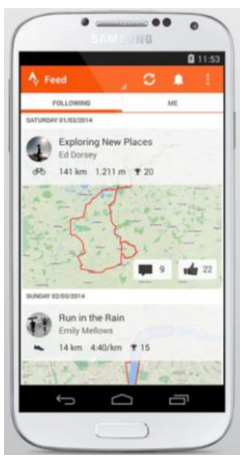
Measurements by ACTIVITY WATCH w/ GPS

Splits

KM	Pace	Elev
0.79	13:43 /km	178 m

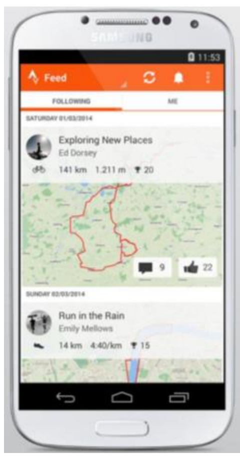


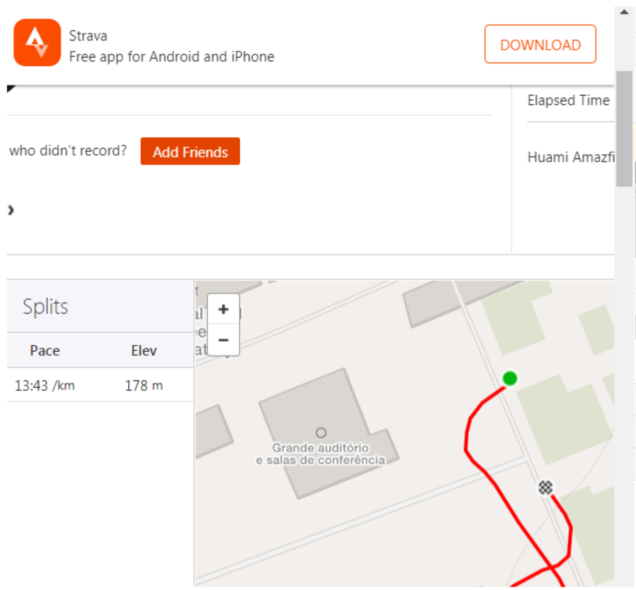
STRAVA™

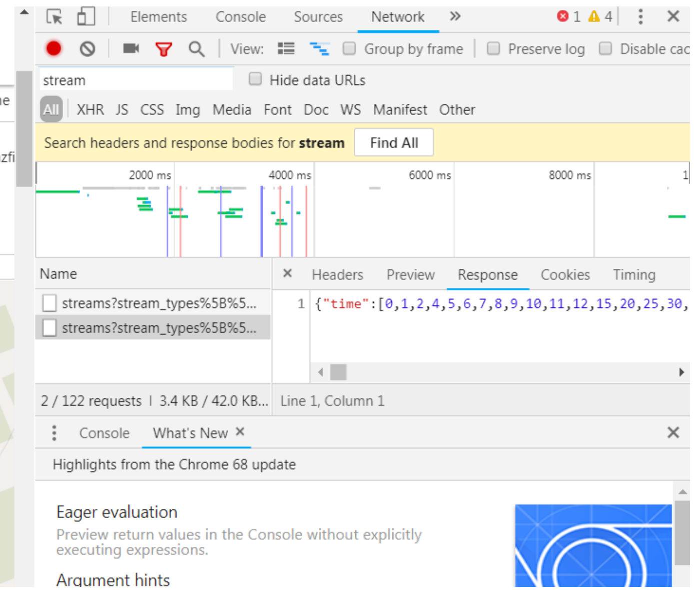


Measurements by ACTIVITY WATCH w/ GPS

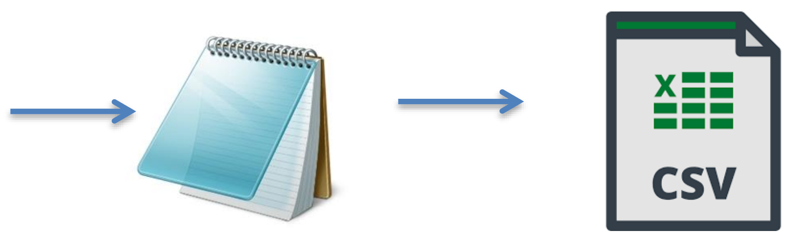
STRAVA™





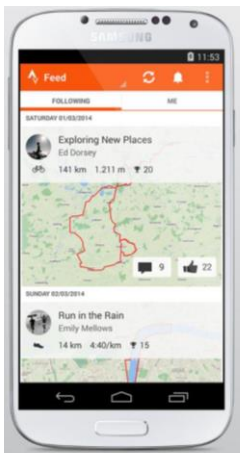


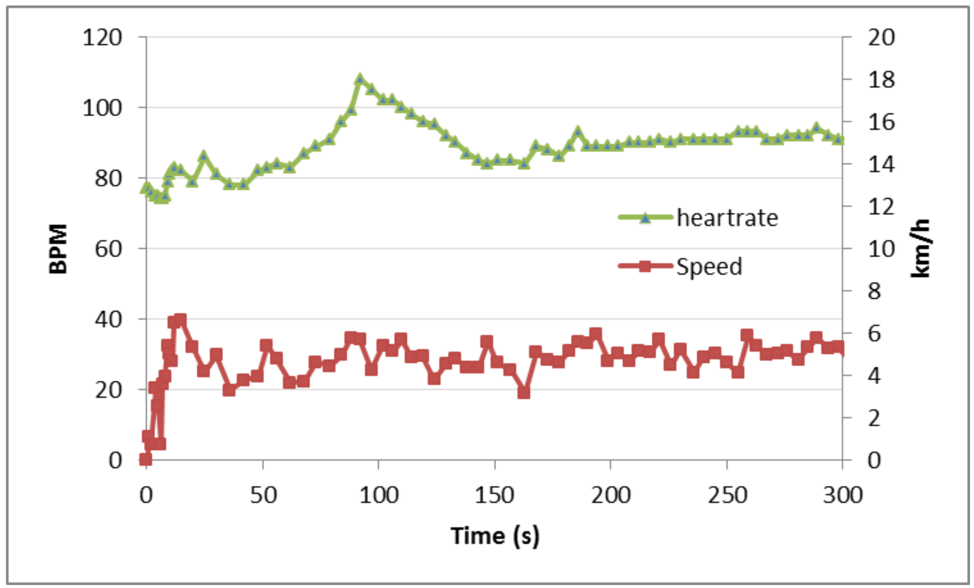
Mouse right click;
Inspect;
Network;
Filter by “stream”;
Select Response;



Measurements by ACTIVITY WATCH w/ GPS

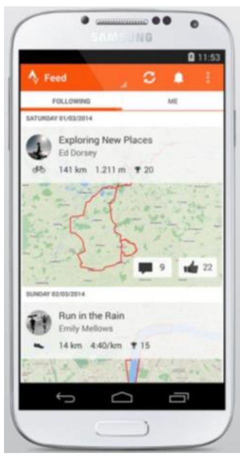
STRAVA™

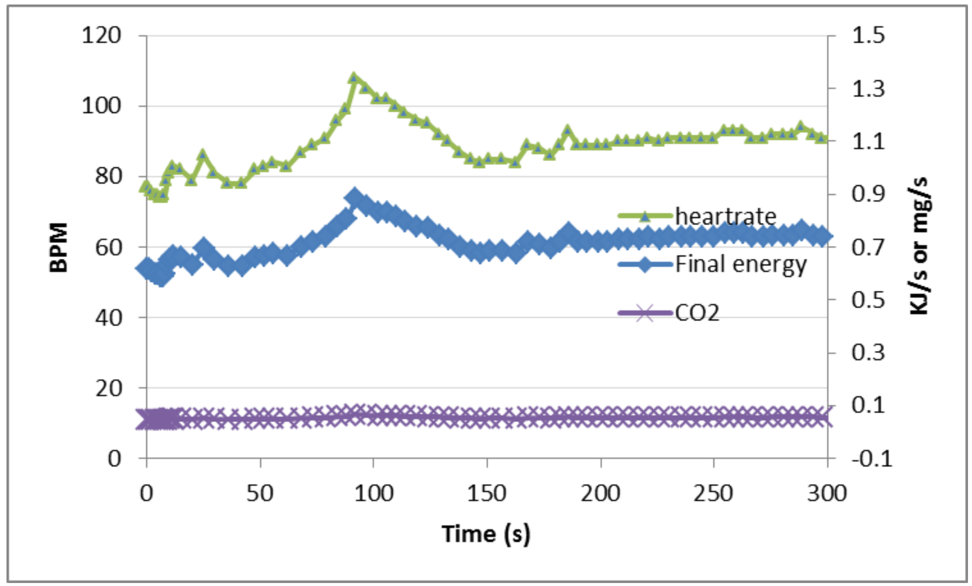




Measurements by ACTIVITY WATCH w/ GPS

STRAVA





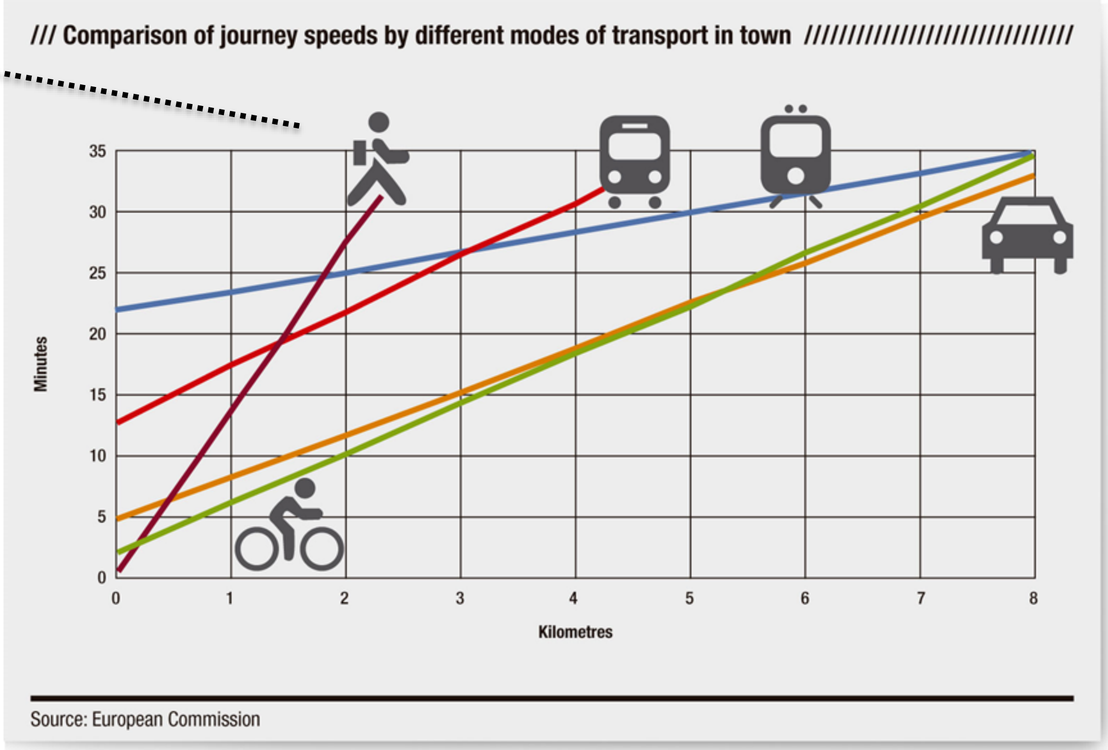
distance 0.8 km
bpm 89 bpm
time 644.64 seconds
Speed 4.5 km/h

Correlation #1 $\frac{Walk-Basal}{Distance}$ **0.14286** MJ/pkm **0.010** g/pkm

Correlation #2 $\frac{Combined}{Distance}$ **0.170023** MJ/pkm **0.012** g/pkm

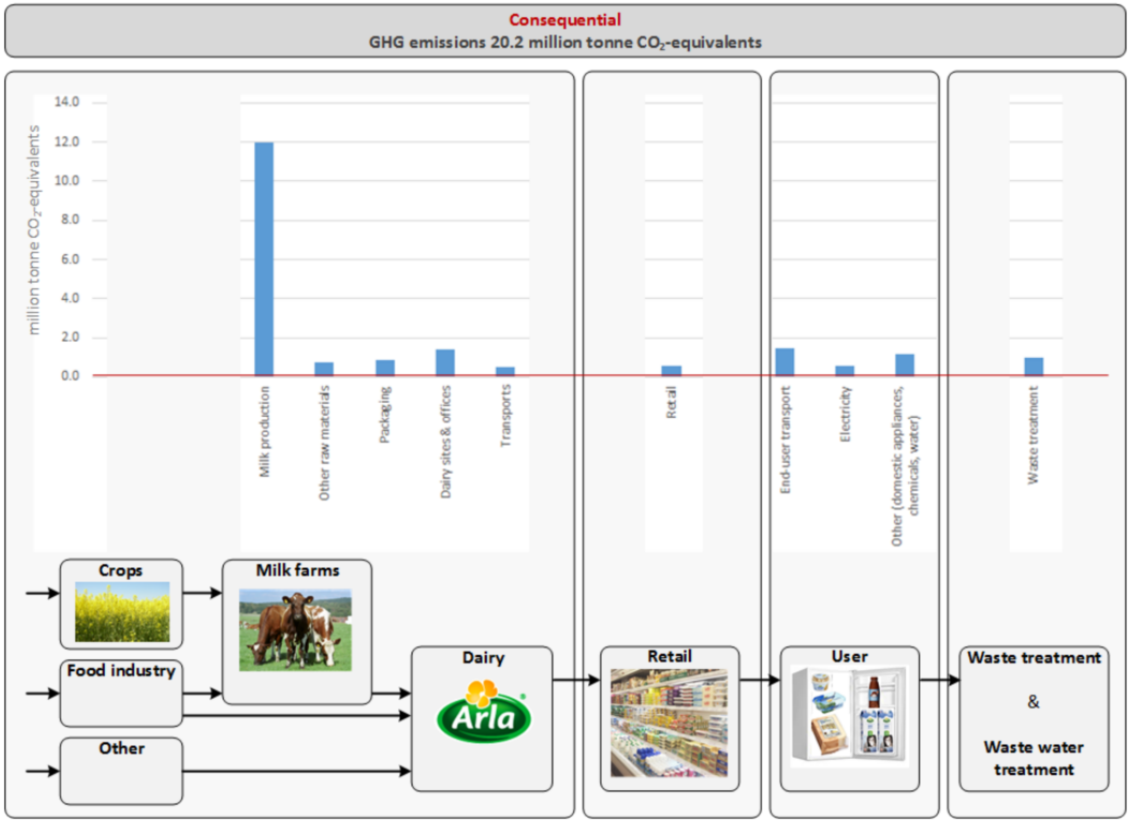
Total travel times

~ 4.5 km/h



Exercices

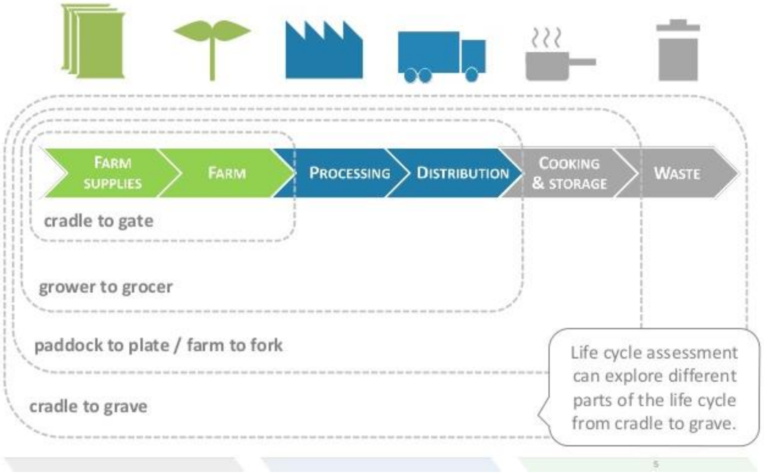
Exercice #1 Identify the final energy consumption and direct emissions in these mobility examples.

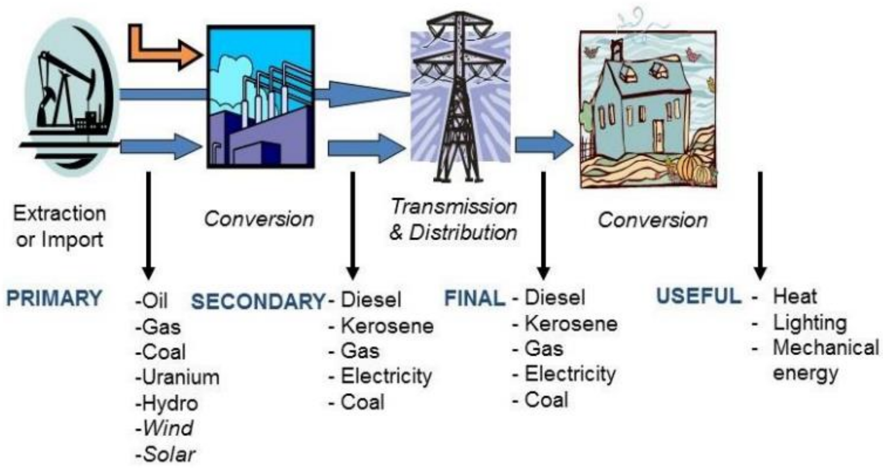


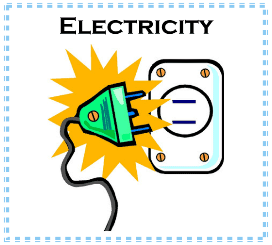
FIGUR. ILLUSTRATION OF BIDRAGENE TIL DRIVHUSEFFEKT FRA DE FORSKELLIGE LIVSCYKLUSFASER. KONSEKVENS LCA.

Exercices

Exercice #1 Identify the final energy consumption and direct emissions in these examples.



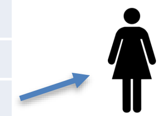




Exercises

Exercice #2 Identify the final energy consumtpion in MJ/pkm MJ/year and CO_2 emissions in g/pkm kg/year, for this imaginarium location; population 10 people! In commuting 2 km.

Height (cm)	Weight (kg)	BPM basal	BPM exercise	Age	Sex		T (s)
171	53	68	128	17	M	Luis	32
165	55	56	108	17	F	Joana	34
183	62	89	160	15	M	João	37
174	67	68	116	17	M	Francisco	41
183	73	76	104	17	M	João	42



shutterstock.com • 140323552

	Height (cm)	W (kg)	BPM basal	BPM walking	A	Sex	T (s)
largarida	161	63	76	88	17	F	137
atarina	161	54	76	84	16	F	133
lariana	164	60	80	160	16	F	43
Joana	158	47.5	64	84	16	F	126.6
lariana	178	60	76	92	16	F	126.6

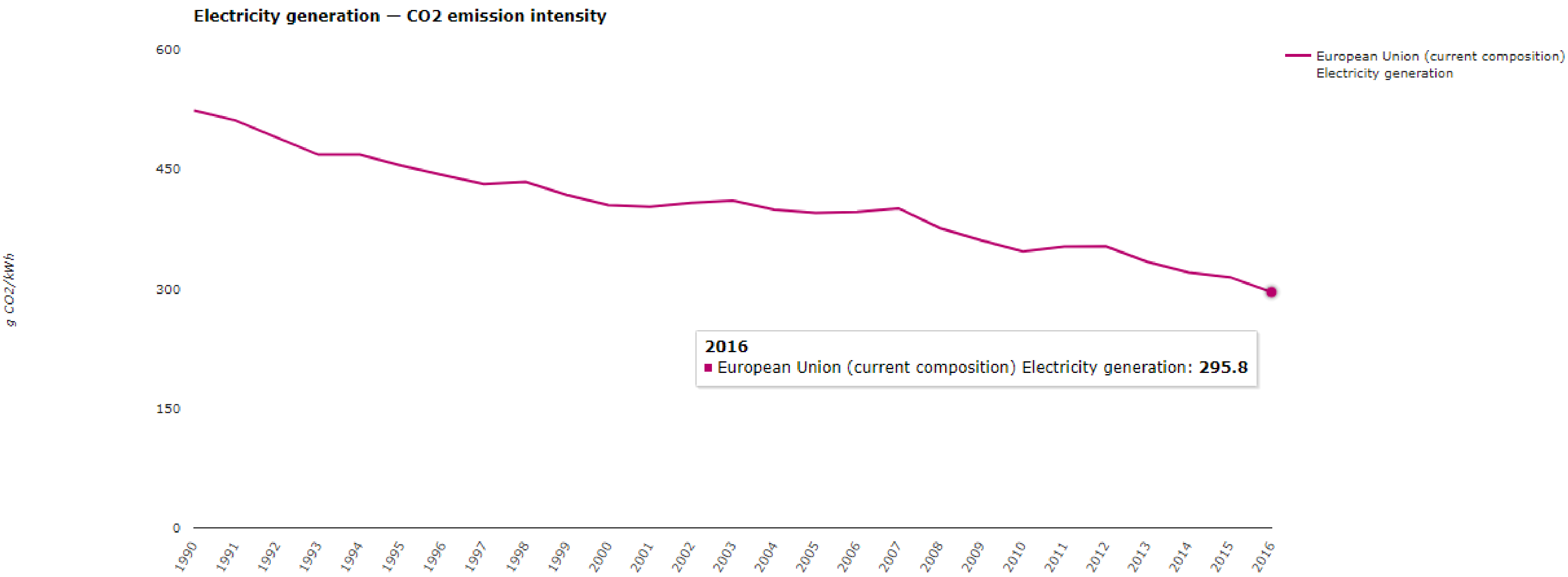
Exercises

Exercice #3 Identify the final energy consumtpion in MJ/pkm and CO_2 emissions in g/pkm for this imaginarium location; population 10 people! In commuting 2 km.

E-bike (speed limit 22 km/h)

Case study, change from convencional bikes to eletric bikes ? What will happen?

Exercice #3 supplemental information



Exercises

Exercice #3 supplemental information

ETSAP ENERGY TECHNOLOGY SYSTEMS ANALYSIS PROGRAMME

iea Energy Technology Network

Table 3 - Electric power transmission and distribution losses (% of output) [8]

Country Name	2005	2006	2007	2008	2009	2010
Arab World	12.41	11.49	12.37	13.24	13.24	12.41
Caribbean small states	8.58	9.29	7.26	6.06	4.34	11.60
East Asia & Pacific (all income levels)	6.35	6.18	6.01	5.96	5.92	5.89
East Asia & Pacific (developing only)	7.42	7.06	6.78	6.60	6.41	6.46
Euro area	6.09	5.34	5.41	5.34	5.29	5.09
Europe & Central Asia (all income levels)	8.57	8.03	7.95	7.89	7.97	7.68
Europe & Central Asia (developing only)	13.29	13.09	13.05	12.68	13.07	12.43
European Union	6.67	6.08	6.12	6.07	6.08	5.86
Heavily indebted poor countries (HIPC)	17.18	16.41	16.10	16.96	16.27	17.67
Latin America & Caribbean (all income levels)	16.18	16.37	16.24	15.95	16.23	15.31
Latin America & Caribbean (developing only)	16.57	16.80	16.76	16.44	16.63	15.74
Least developed countries: UN classification	14.91	13.35	13.49	13.47	12.31	12.03
Middle East & North Africa (all income levels)	13.04	12.46	13.19	13.48	13.16	12.29
Middle East & North Africa (developing only)	16.13	16.23	17.35	17.65	17.08	15.41
North America	6.37	6.44	6.45	6.17	6.93	6.58
OECD members	6.48	6.34	6.32	6.21	6.60	6.33
Other small states	22.08	21.68	24.84	21.51	23.09	20.45
South Asia	24.93	23.41	21.83	21.24	21.06	20.66
Sub-Saharan Africa (all income levels)	11.26	11.63	10.23	10.57	11.00	11.79
Sub-Saharan Africa (developing only)	11.26	11.63	10.23	10.57	11.00	11.79
World	8.84	8.61	8.47	8.37	8.62	8.31

Bike

Battery 1,12 kWh

Eletric motor 3 kW

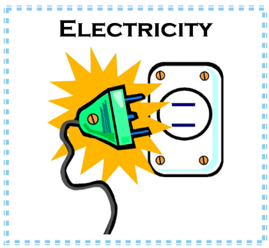
Top speed 24 km/h

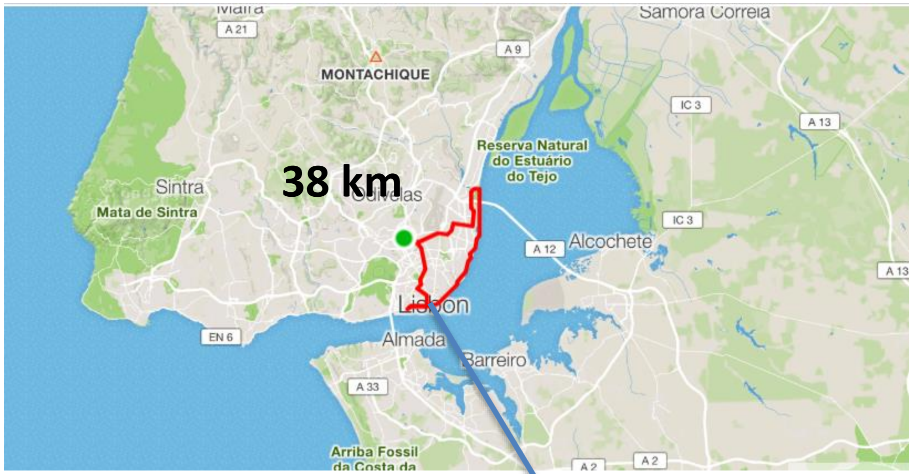
Final energy

MJ/pkm???

E-Bike Example

Real use Final energy MJ/pkm???biogenic vs eletric

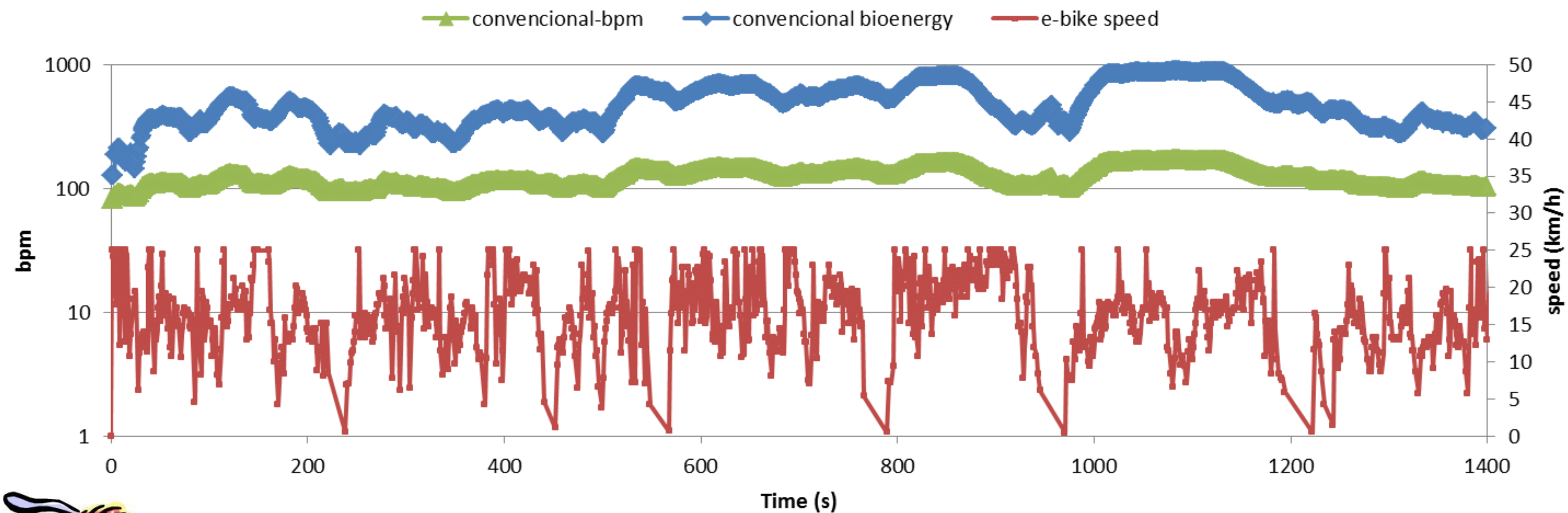




E-bike swap

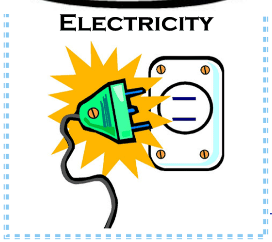
E-Bike Example

Representation first 5 km



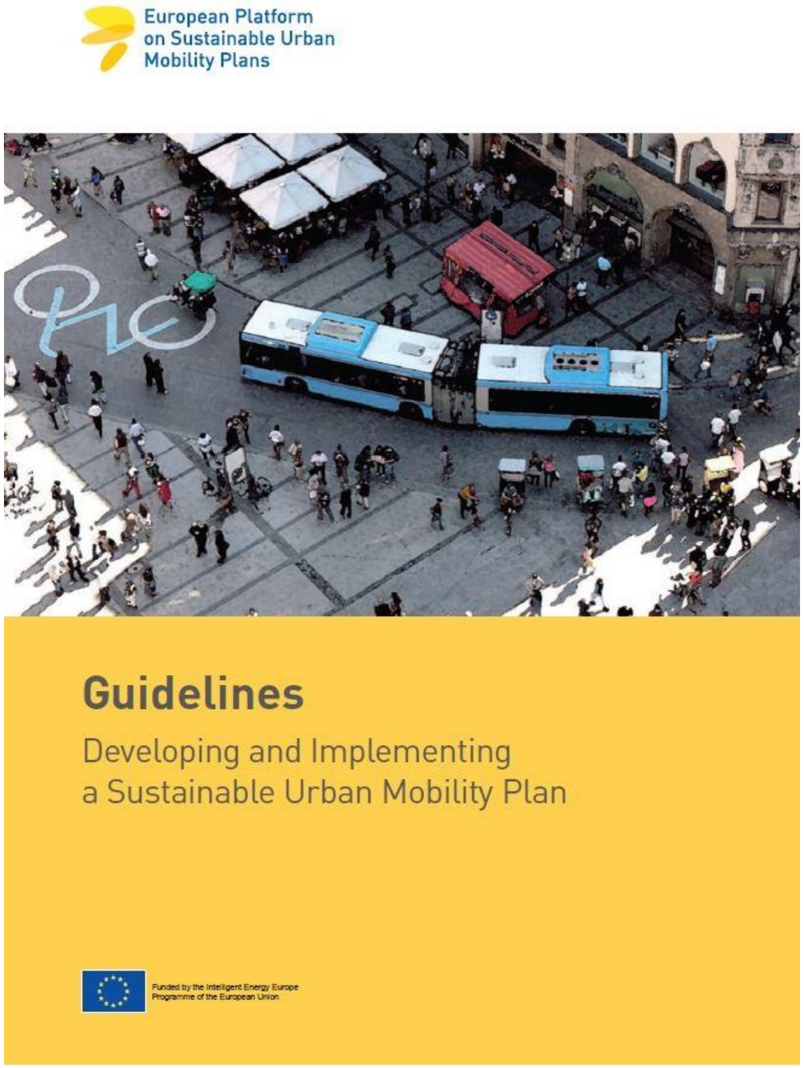
~ 0.14 MJ/pkm

Overall 500 m elevation gain……

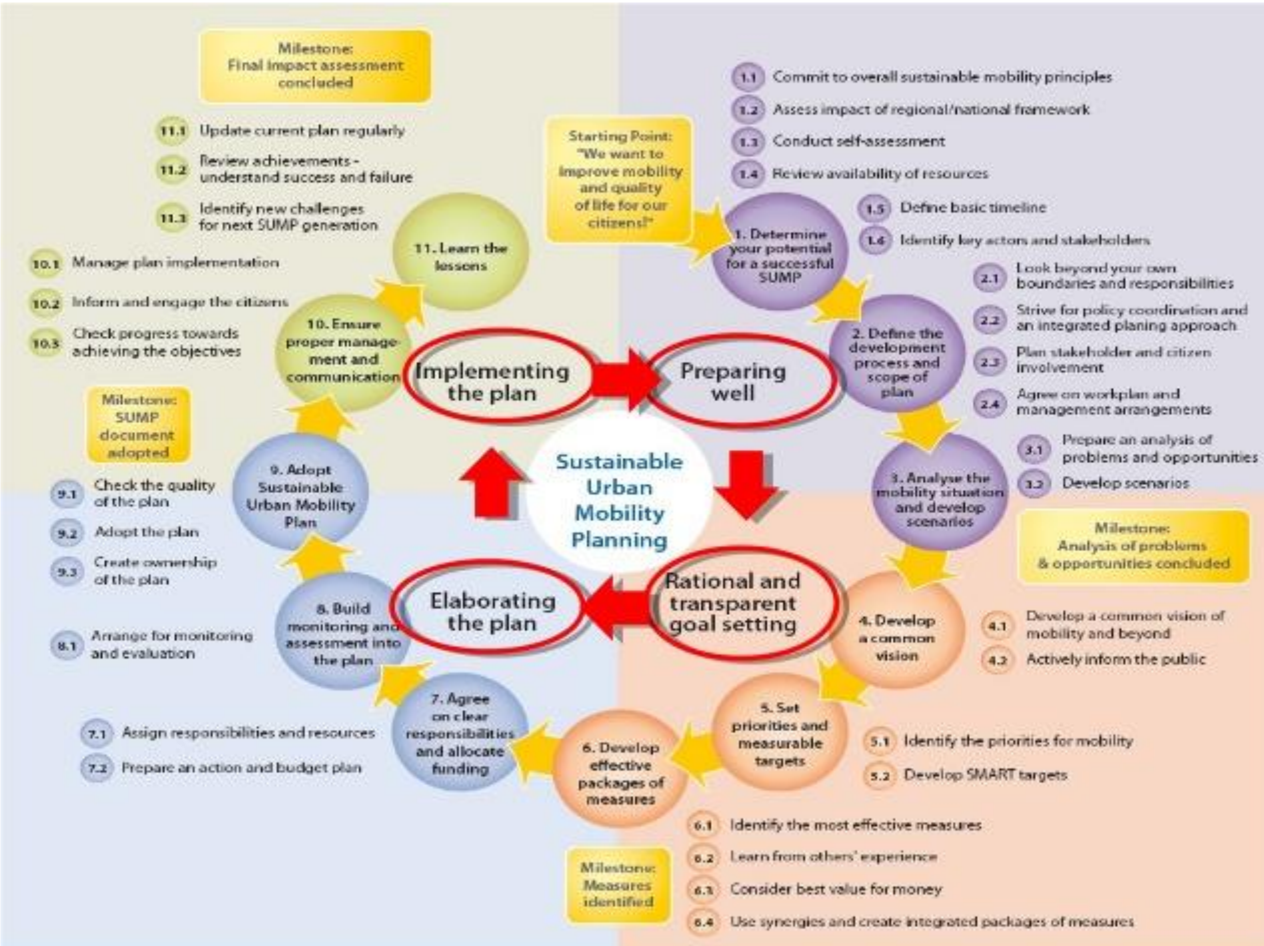


Real range: 30 km spent 1.12 kWh → 1.12/30 * 3.6 = **0.13 MJ/pkm final energy electricity**

SUMP - Sustainable urban mobility plans



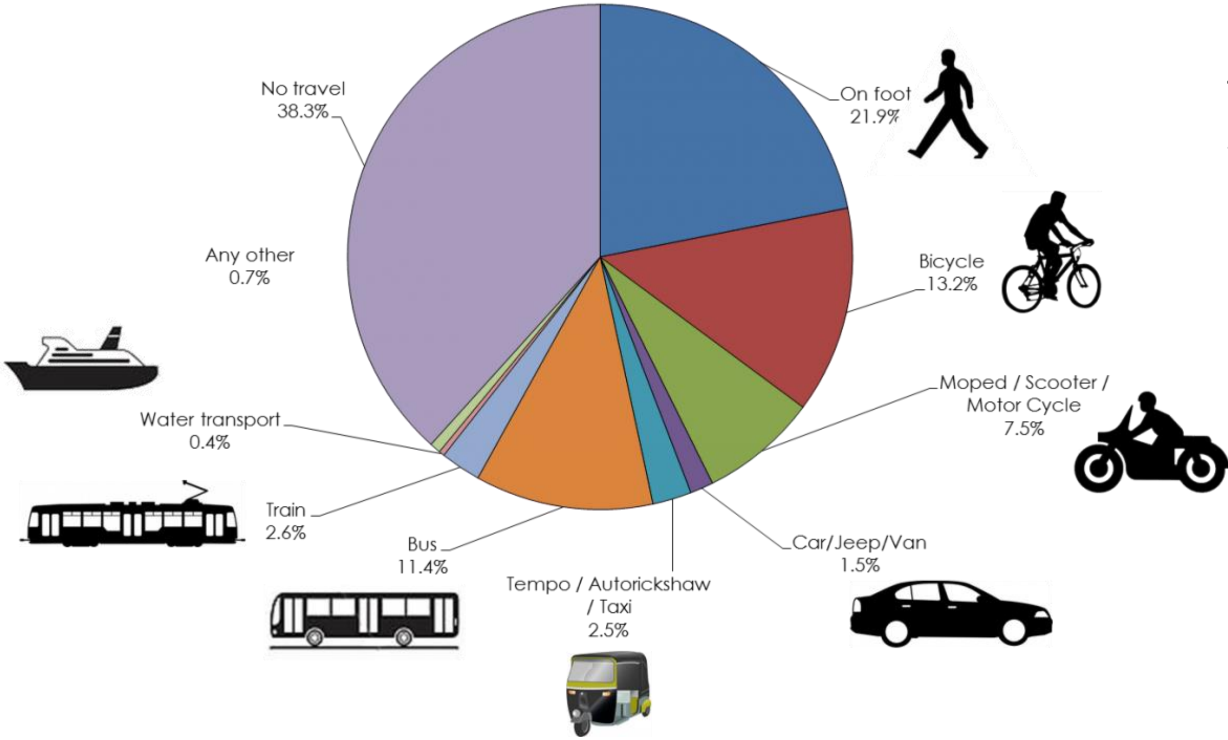
SUMP - Sustainable mobility plans



Characterization of current status
SURVEYS

Vision for the future
Scenario building

Knowing how people move???

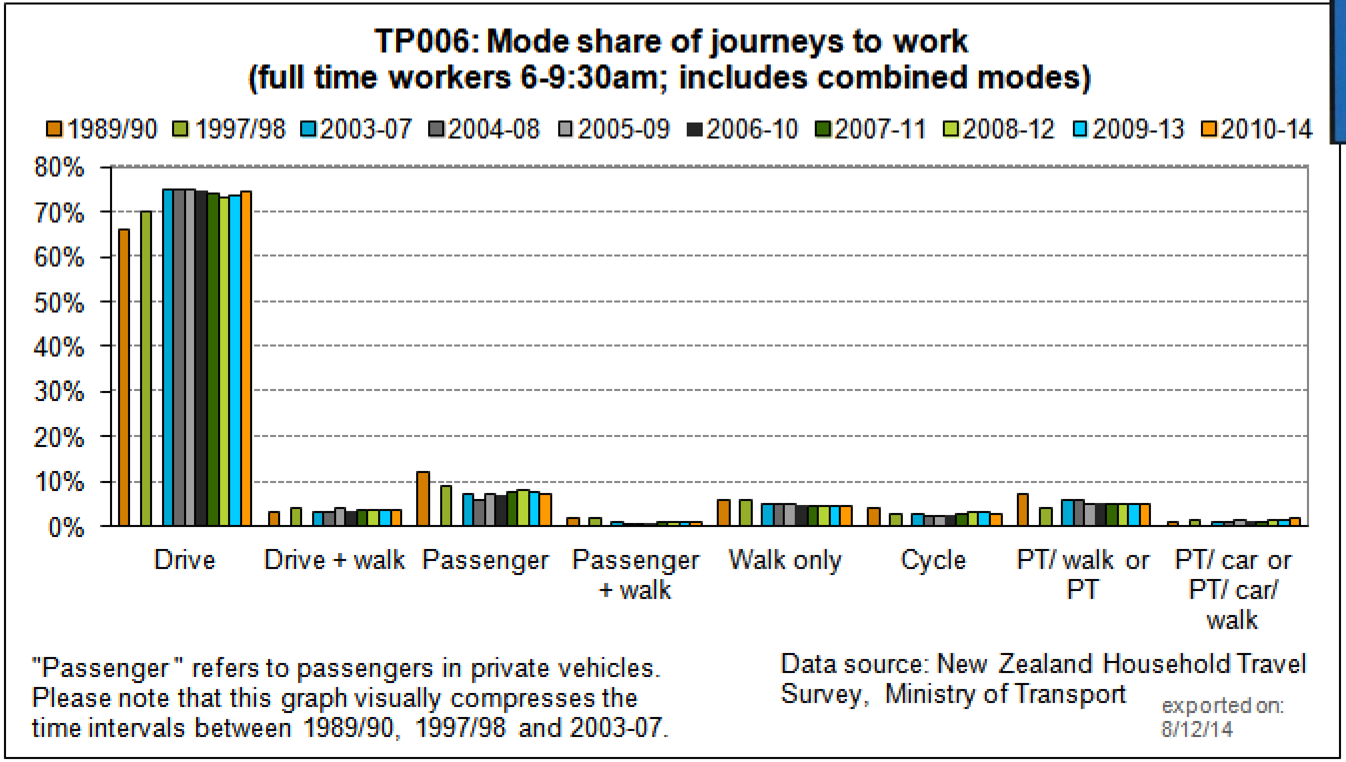


Travel to work by modes of transport, 2011.

100% = 200.4 million.

Surveys….

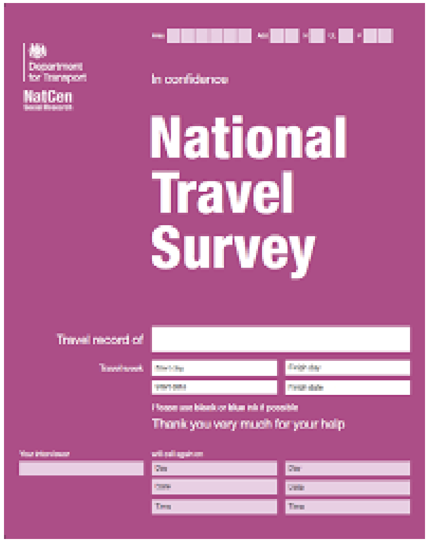
Knowing how people move???



Surveys….

Surveys

How people travel?



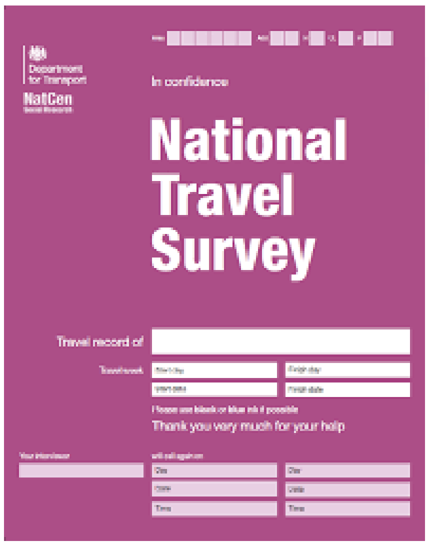
Why people travel?

How people travel?

When people travel?

Surveys

How people travel?



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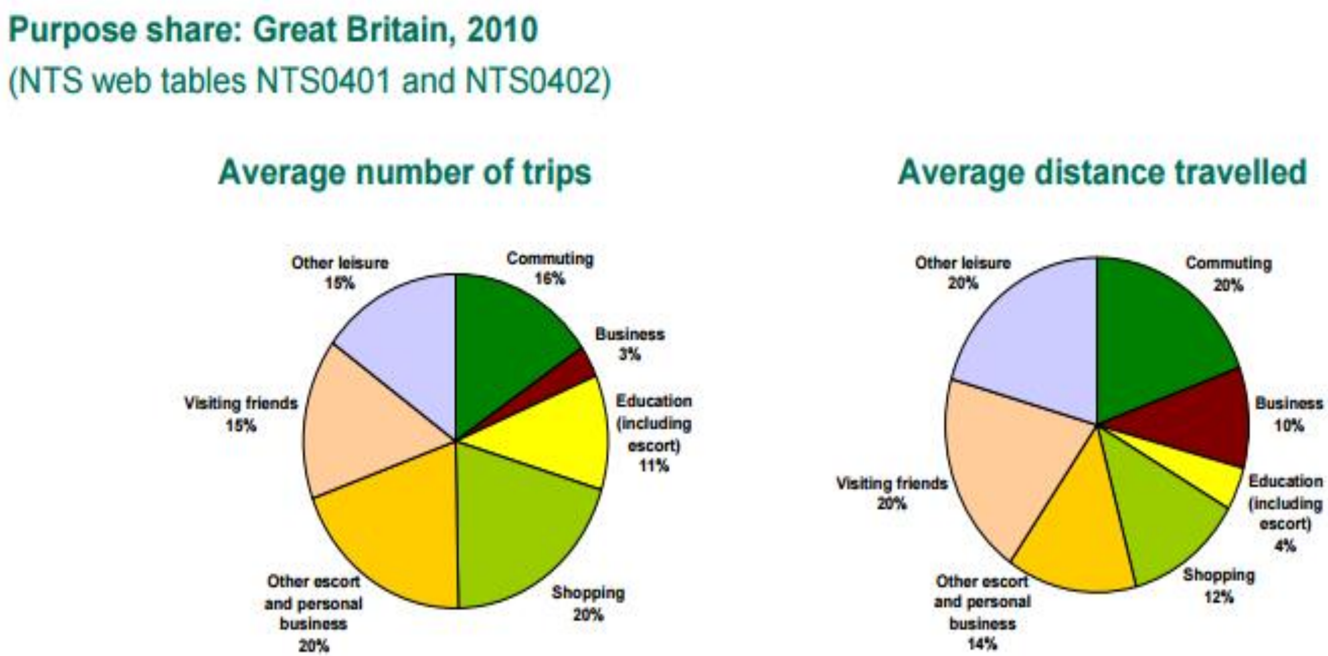
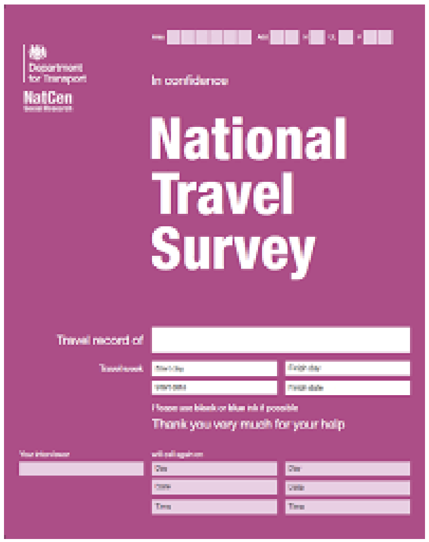


How people travel?



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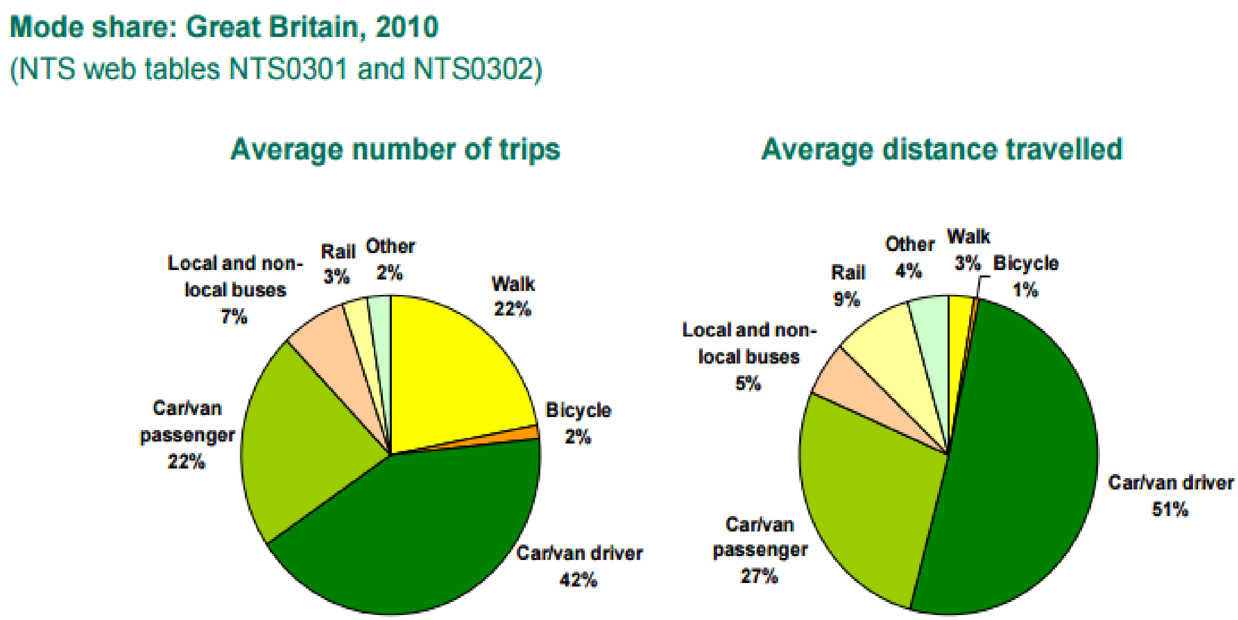

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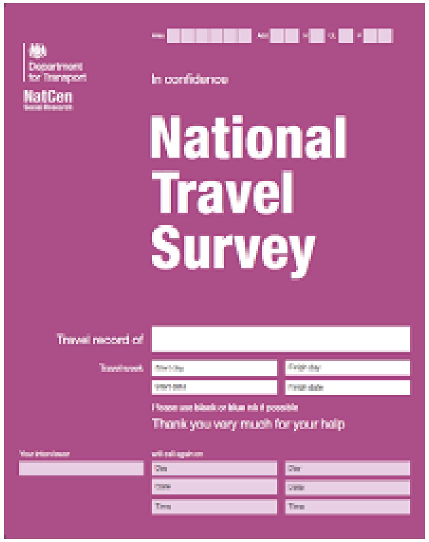
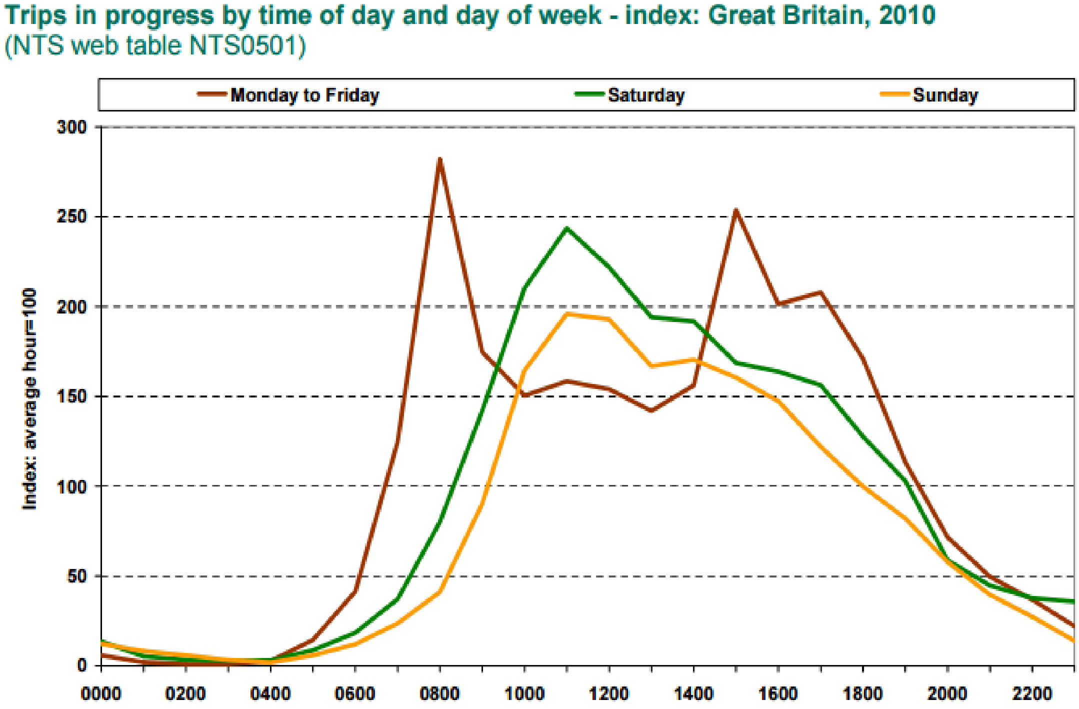
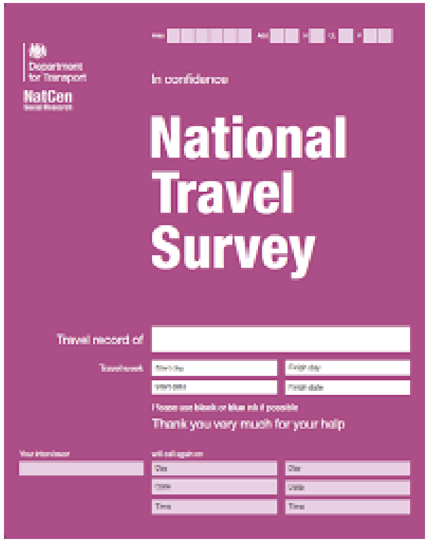


When people travel?



Surveys

How people travel?



Why people travel?

How people travel?

When people travel?

Surveys

CENSOS 2011

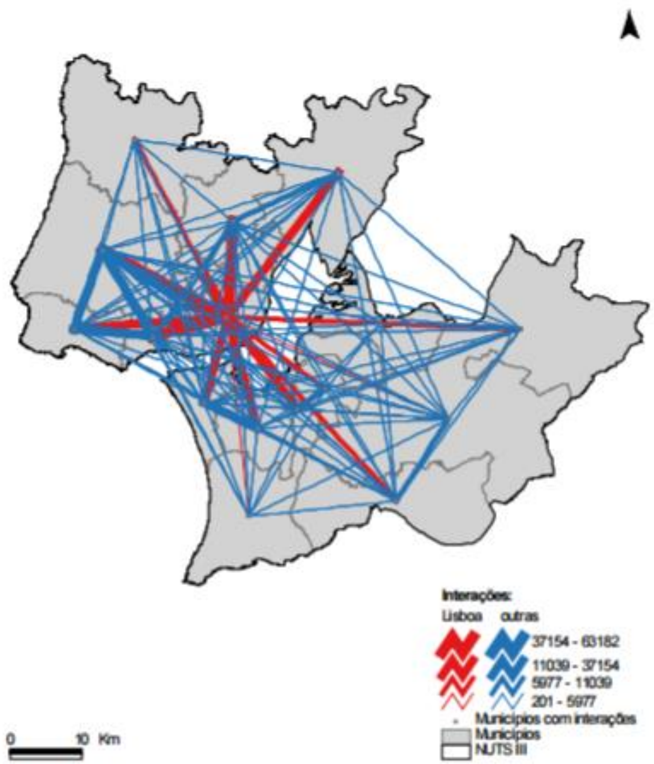
XV recenseamento geral da população
V recenseamento geral da habitação

RESULTADOS DEFINITIVOS

LISBOA

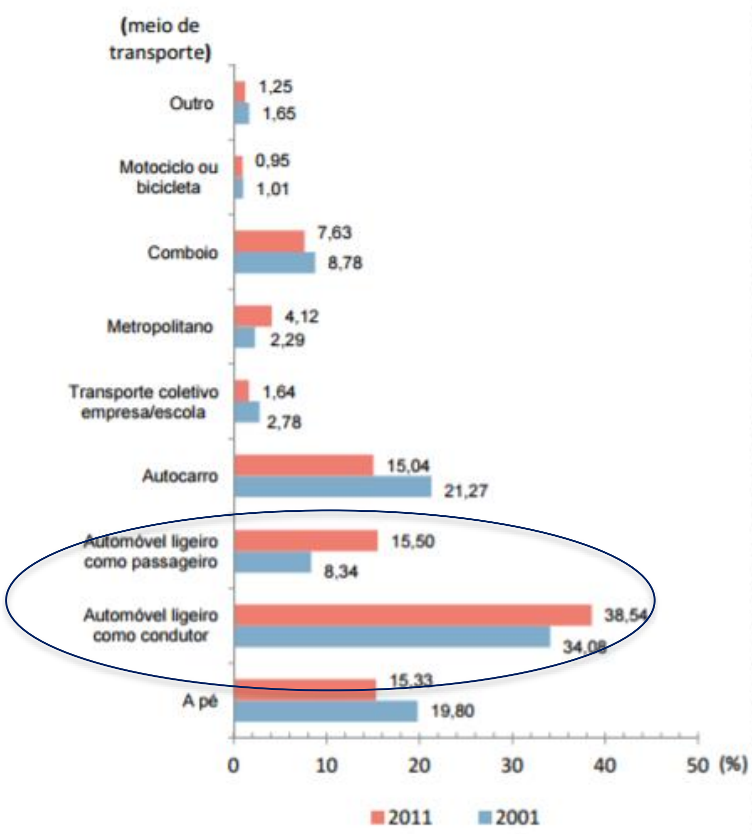
Surveys

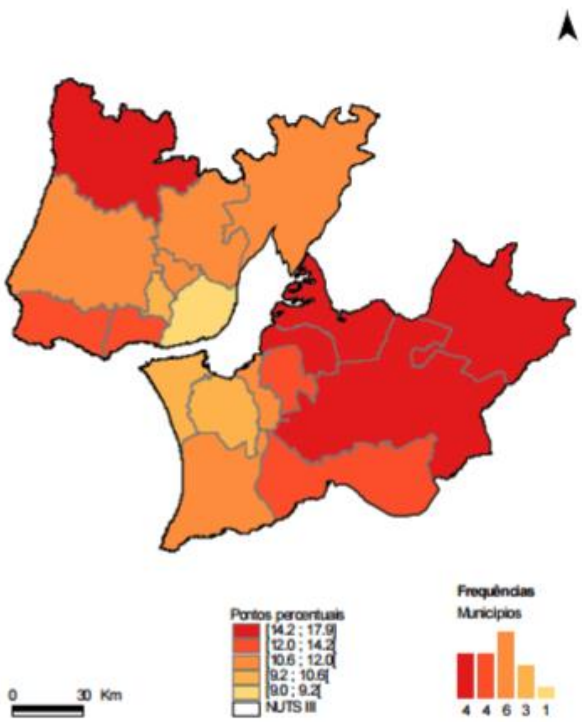
Commuting(regional interactions), 2011



Surveys

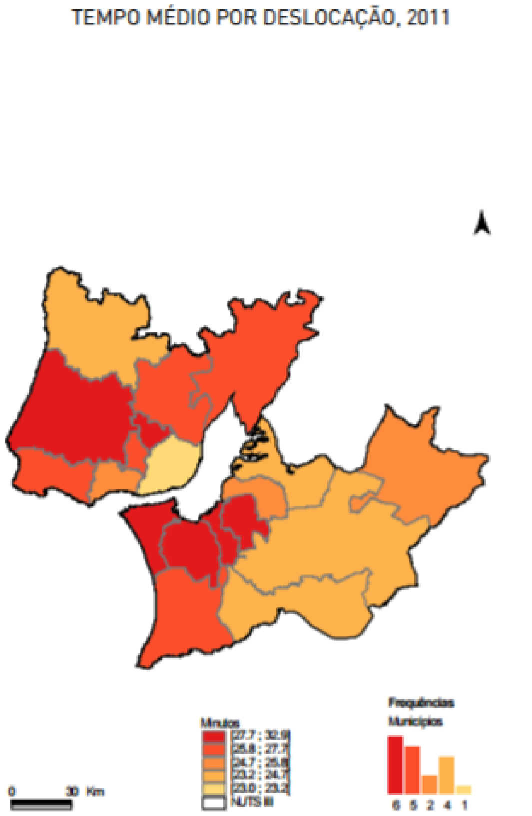
Means of transport in commuting

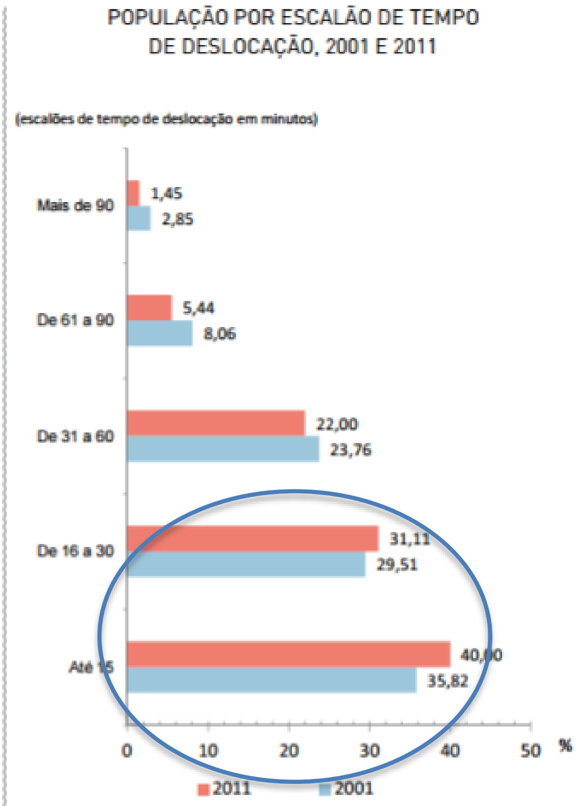




Surveys

Average time in commuting (average 30 min 2001; 26 min 2011)



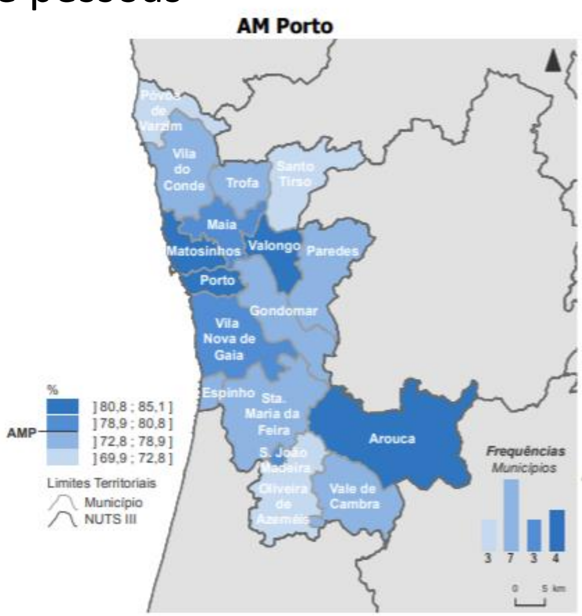


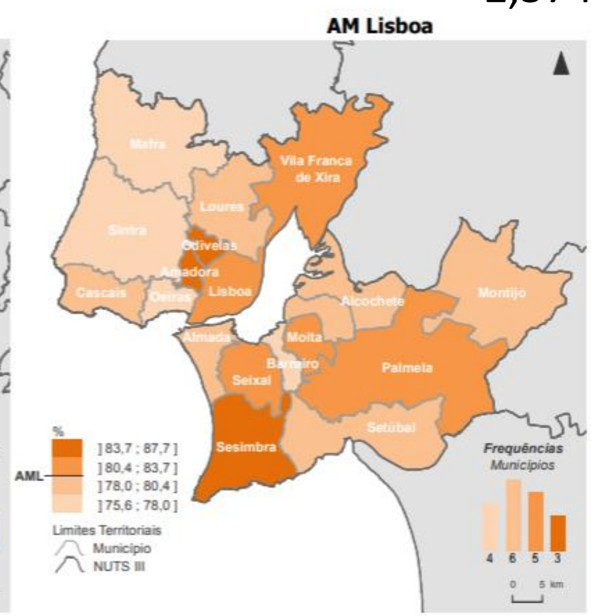
Surveys

Recent mobility survey 2017 Porto and Lisbon

1,60 milhões de pessoas

2,57 milhões de pessoas





Surveys

Recent mobility survey 2017 Porto and Lisbon

46 080 valid answers, 18169 na AMP e 27911 na AML, contemplando um total de 99144 indivíduos (40393 na AMP e 58751 na AML).

Campain: October-December 2017

1st **Web (Computer Assisted Web Interview-CAWI**)

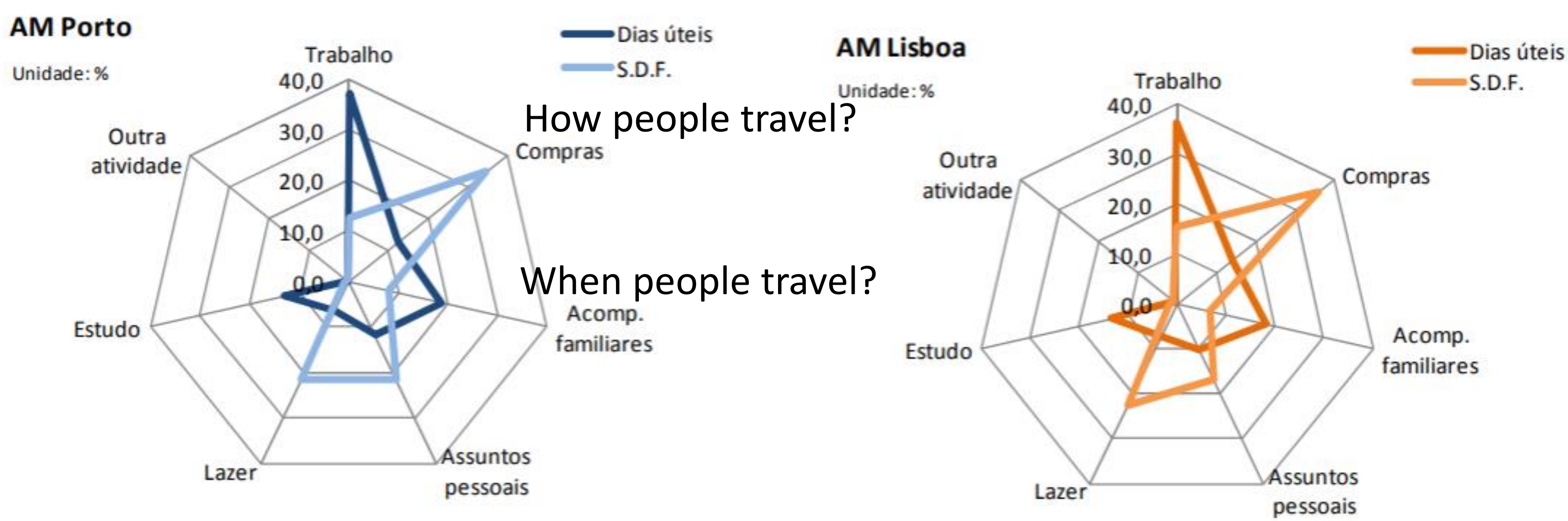
2nd Face to face interviews(**Computer Assisted Personal Interview-CAPI**) for the non respondants 1st stage.

Surveys

Recent mobility survey 2017 Porto and Lisbon

Why people travel?

Figura 16 – Distribuição do número de deslocações por motivo de deslocação (excluindo "regresso a casa")



How people travel?

When people travel?

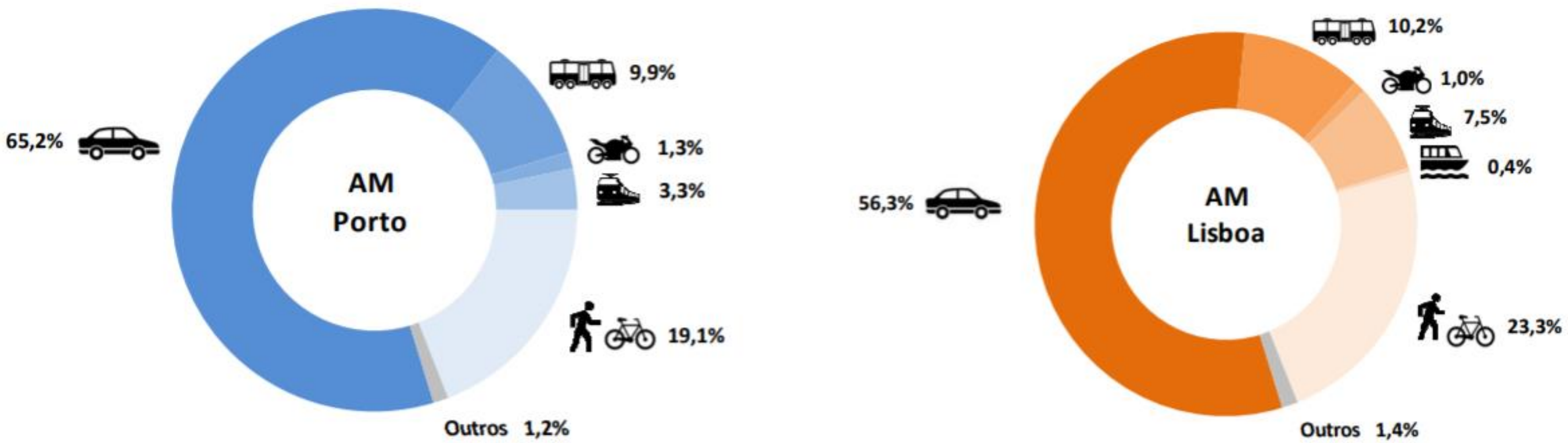
Surveys

Recent mobility survey 2017 Porto and Lisbon

How people travel?

Figura 18 – Distribuição do número de deslocações por principal meio de transporte, nos dias úteis

(globalidade dos meios de transporte)



Surveys

Recent mobility survey 2017 Porto and Lisbon

How fast people travel?

Average 30 km/h

Why car?

- Speed;
- Confort;
- No public transport direct connection between origin and destination.

Surveys

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:10^3

	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**
Automóvel - condutor	17,326.3	12,334.4	4,992.0
Automóvel - passageiro	4,884.7	3,110.2	1,774.5
Motociclo/ciclomotor	331.3	270.9	60.4
Transporte público ou coletivo	**5,939.5**	**5,056.6**	**882.9**
Dos quais:			
Autocarro	2,945.9	2,476.0	469.9
Comboio	1,215.7	1,032.0	183.7
Metropolitano	1,167.8	1,014.6	153.2
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

Surveys

Recent mobility survey 2017 Porto and Lisbon

Impact of people travel?

km per trip

Quadro 9

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

AM Lisboa

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

Nota: Exclui as deslocações internacionais

Surveys

Recent mobility survey 2017 Porto and Lisbon

Impact of people travel?

$$\Sigma_i(\text{Number trip}_i \text{ X km per trip}_i \text{ X EC}_i)$$

$_i$ mode of transport

EC_i final energy consumption by mode (MJ/pkm)

Surveys

Surveys

1st design
2nd test in a few people
3rd did you get the info you needed?

No

Yes!
Ready to go...

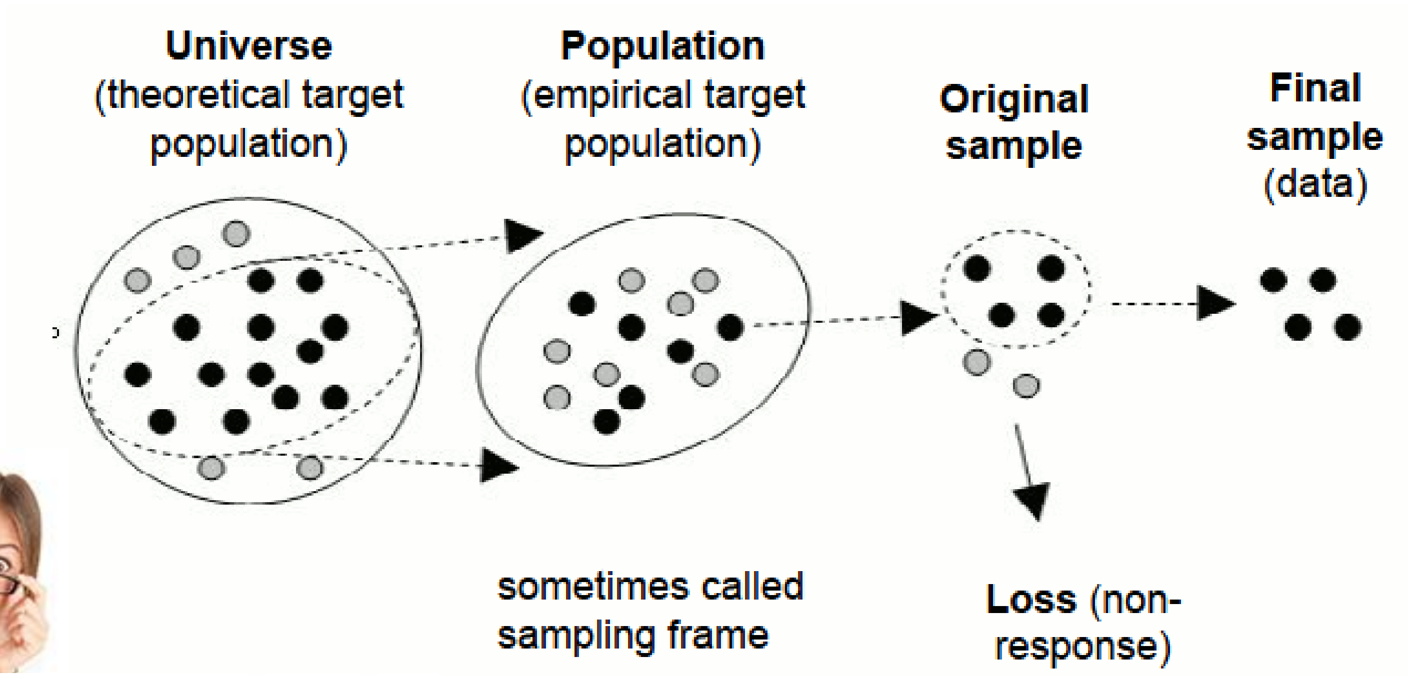
On-line

surveygizmo
SurveyMonkey
QuestionPro
Google Forms

In person

Surveys

How people travel?



Carla Silva camsilva@fc.ul.pt

1st assignment

How people travel? 2017 FCUL survey

(overall population, students, professores, researchers, others)

- Origin -destination distance
- Transportation mode
- Commuting duration and average speed
- Car ownership (#cars per #family) comparison with national average
- Location parking for those who use the car

1st assignment

How people travel? 2017 FCUL survey

- Why not public transport for those who use car
- Rush hours (morning peak and afternoon peak)
- Willingness to drive an EV?
- Willingness to use carsharing?
- Willingness to use carpooling?
- Willingness to use bikesharing?
- Willingness to be on na autonomous car/drive and a full autonomous car

1st assignment

How people travel? 2017 FCUL survey due 10 november

- emissions per capita

CO_2
PM 10
NO_x
CO_2eq per year WTT and TTW

and…..as additional conclusions

- Main difficulties dealing with the file?

- Lessons learned

You learned....

- First steps in a sustainable mobility plan;
- Mobility measures;
- How to design a survey to get the right answers;
- Final energy consumption/emission estimation from surveys.

Obrigado

Ciências
ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa