Energy Management– Energy in Transports
1^{st} semester 2013/2014

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OUTLINE

- Passenger and Freight
- Basics units
- Statistics
- Legislation
- Mitigation strategies
- Vehicle dynamics
- Life cycle notion
- Exercises

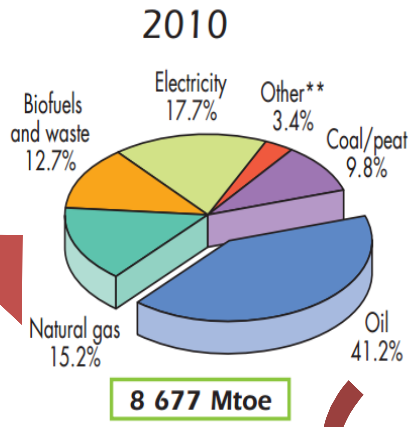
 E-mail: carla.silva@ist.utl.pt

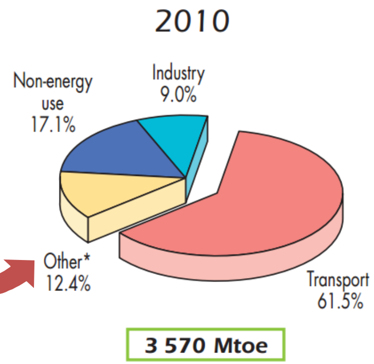
- Passenger and Freight






Meeting the Needs of 6 Billion People





@ International Energy Agency, 2012

1 toe = 41.868 GJ or 11.63 MWh

the amount of energy released by burning one tonne of crude oil

Typical transport energy units and fuel properties

MJ/pkm MJ/tkm MJ/(seat.km) l/100km km/l mpg

		Density at STP (kg/m³)	Ratio of HHV to LHV energy content	Net Calorific Value / LHV (MJ/L)	Net Calorific Value / LHV (MJ/kg)	Gross Calorific Value / HHV (MJ/L)	Gross Calorific Value / HHV (MJ/kg)	Carbon Intensity (g CO_2-eq / MJ LHV)
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
Fuel Oil		959 ± 17	1.058 ± 0.008	39.21 ± 1.09	40.87 ± 0.94	41.50 ± 1.15	43.26 ± 1.00	77.8 ± 2.1
LPG		533 ± 18	1.077 ± 0.008	24.67 ± 0.80	46.28 ± 0.74	26.57 ± 0.86	49.84 ± 0.80	63.9 ± 2.1
Kerosene		807 ± 6	1.053 ± 0.001	35.24 ± 0.41	43.69 ± 0.51	37.10 ± 0.43	45.99 ± 0.54	72.0 ± 1.8
Hydrogen	(35 MPa)	23.65 ± 0.09	1.183 ± 0.001	2.837 ± 0.003	119.95 ± 0.13	3.355 ± 0.004	141.88 ± 0.16	0
	(70 MPa)	39.69 ± 0.16		4.761 ± 0.005		5.631 ± 0.006		
	(liquid)	72.41 ± 0.72		8.685 ± 0.010		10.273 ± 0.011		
		(kg/m³)	**(HHV / LHV)**		**(MJ/kg)**		**(MJ/kg)**	**(g/MJ LHV)**
Coal			1.050 ± 0.004	-	25.75 ± 2.64	-	27.05 ± 2.77	95.7 ± 7.0
		(kg/m³)	**(HHV / LHV)**	**(MJ/m³)**	**(MJ/kg)**	**(MJ/m³)**	**(MJ/kg)**	**(g/MJ LHV)**
Natural Gas		0.768 ± 0.039	1.109 ± 0.003	35.22 ± 2.22	45.86 ± 3.95	39.05 ± 2.47	50.84 ± 4.38	56.9 ± 3.4
Hydrogen	(1 atm.)	0.0838 ± 0.0008	1.183 ± 0.001	10.05 ± 0.01	119.95 ± 0.13	11.88 ± 0.01	141.88 ± 0.16	0

http://www.claverton-energy.com/wp-content/uploads/2012/08/the_energy_and_fuel_data_sheet.pdf

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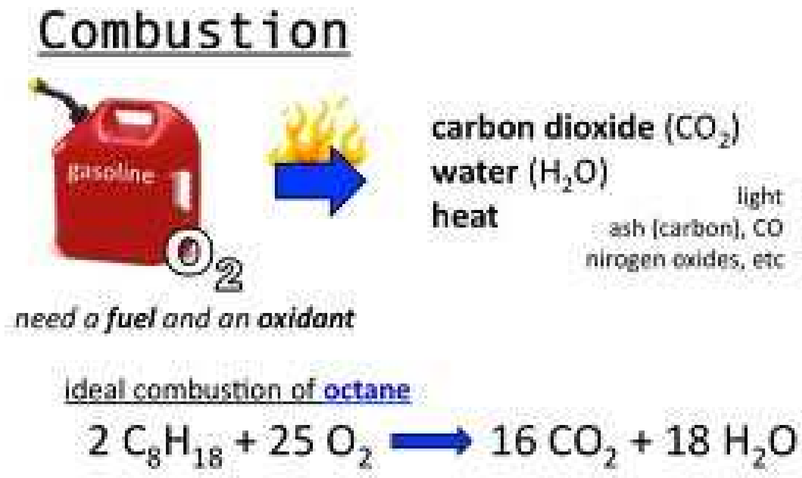
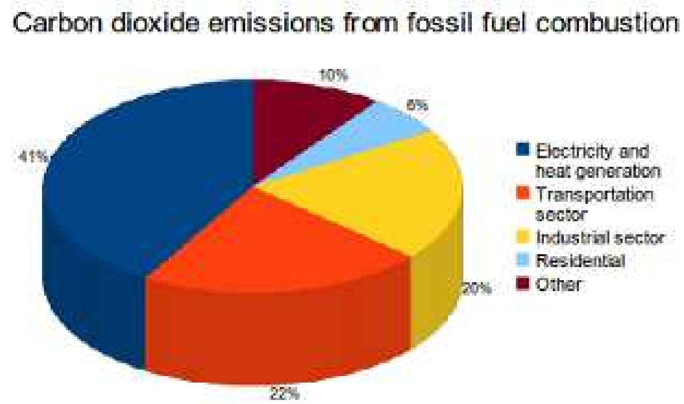


2010 (28 Gton)



1 toe ~ 2.5 tCO_2

Main issue: Combustion emissions mitigation

@ International Energy Agency, 2012

Producers	Mt	% of world total
Saudi Arabia	517	12.9
Russian Federation	510	12.7
United States	346	8.6
Islamic Rep. of Iran	215	5.4
People's Rep. of China	203	5.1
Canada	169	4.2
United Arab Emirates	149	3.7
Venezuela	148	3.7
Mexico	144	3.6
Nigeria	139	3.5
Rest of the world	1 471	36.6
World	**4 011**	**100.0**

2011 data

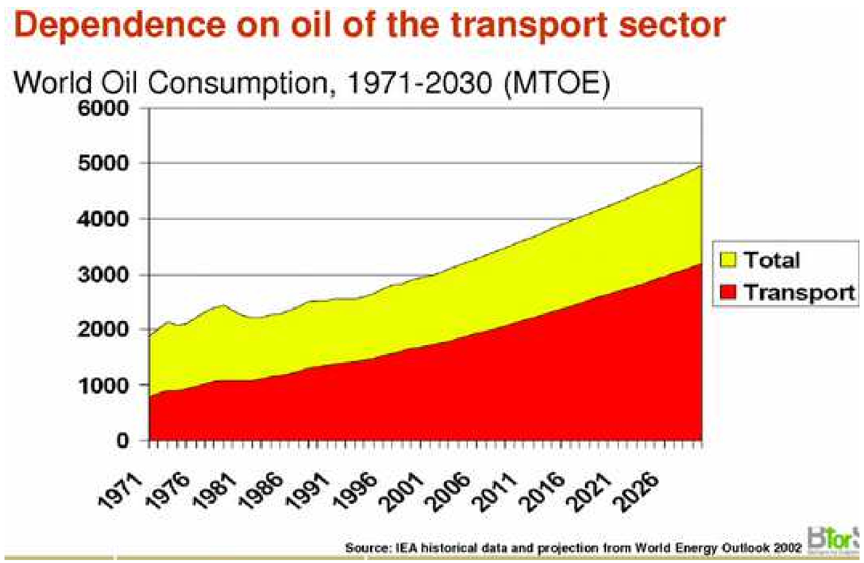
Includes crude oil, NGL, feedstocks, additives and other hydrocarbons.

Net exporters	Mt
Saudi Arabia	333
Russian Federation	246
Nigeria	129
Islamic Rep. of Iran	126
United Arab Emirates	105
Iraq	94
Venezuela	87
Angola	84
Norway	78
Mexico	71
Others	609
Total	**1 962**

2010 data

Net importers	Mt
United States	513
People's Rep. of China	235
Japan	181
India	164
Korea	119
Germany	93
Italy	84
France	64
Netherlands	60
Singapore	57
Others	483
Total	**2 053**

2010 data



Main issue: Oil dependency mitigation

@ International Energy Agency, 2012
http://www.iea.org/publications/freepublications/publication/kwes.pdf

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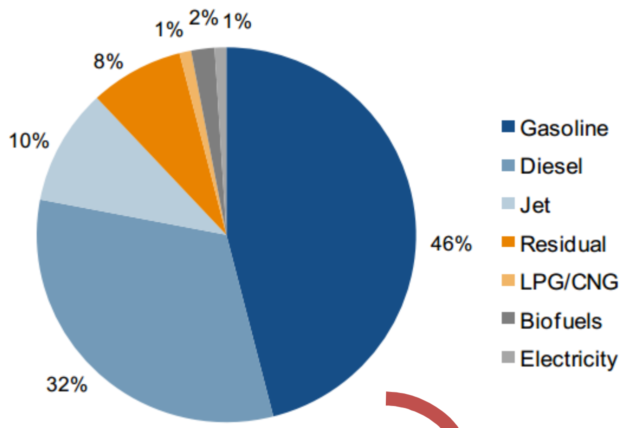
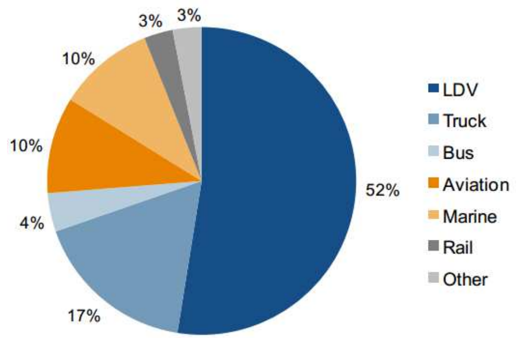
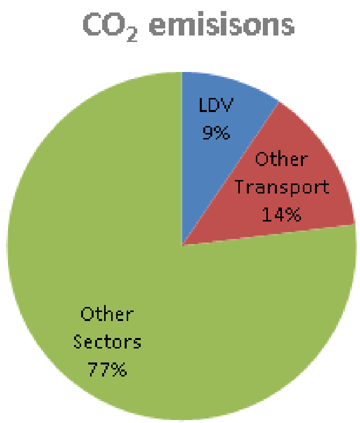
(Transport ~2,200 Mtoe)





(LDV ~2.8 Gton)

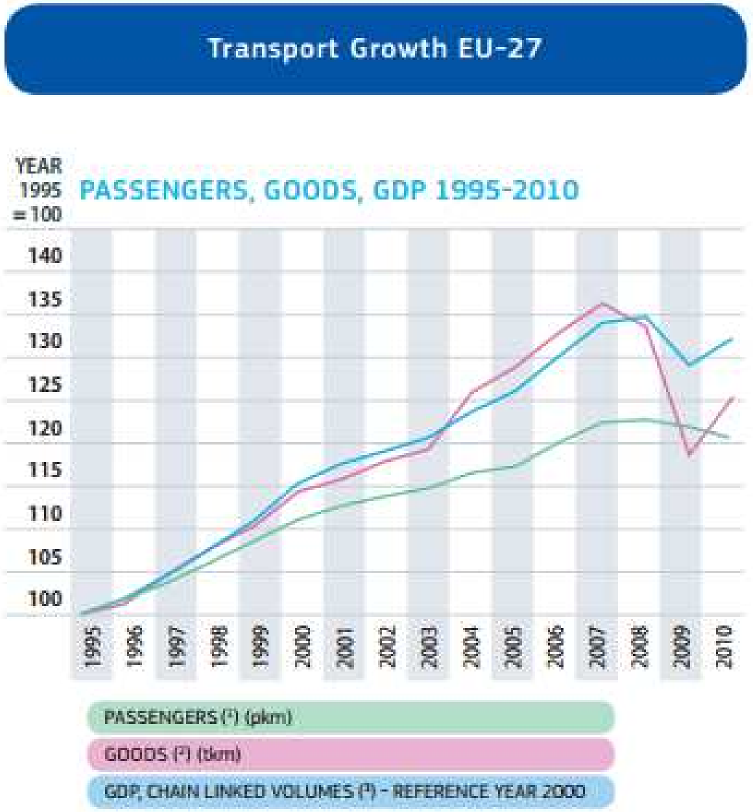


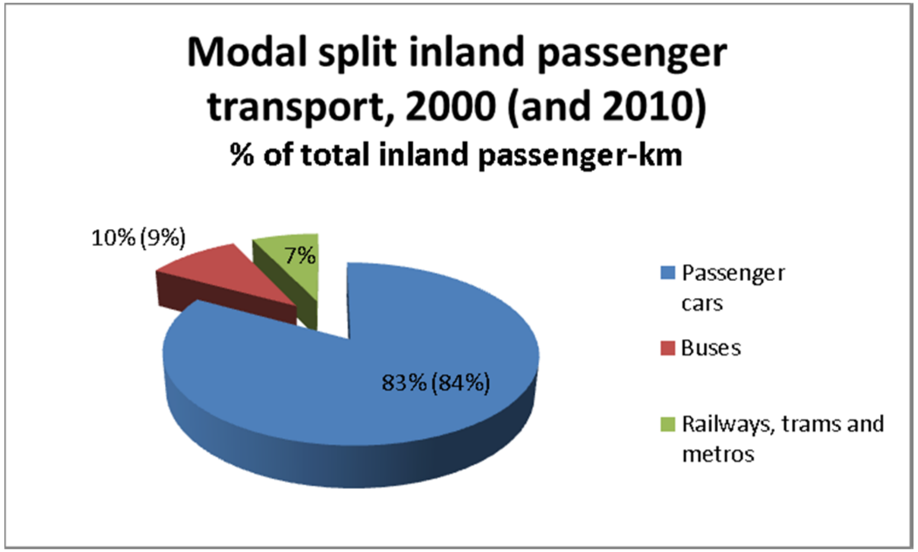
Passenger and Freight

CO_2, N_2O, CH_4

HC, CO, NOx, PM

@ 2010 World Energy Council
http://www.worldenergy.org/documents/wec_transport_scenarios_2050.pdf





@ Energy & Transport in figures 2010
http://ec.europa.eu/transport/facts-fundings/statistics/doc/2012/pocketbook2012.pdf

Energy Management

Table 5.6 *Percentage of trips (not distance) made by various modes of travel in different cities in 2001*

City	Car	Public transportation	Foot	Bike	Foot + bike
Hong Kong	16	46	38	0	38
Moscow	26	49	22	2	24
Warsaw	29	52	19	0	19
Bangalore[a]	29	45	16	11	27
Budapest	33	44	22	1	23
São Paulo	34	29	37	0	37
Amsterdam	34	15	26	26	52
Prague	36	43	20	1	21
Vienna	36	34	27	3	30
Berlin	39	25	26	10	36
Helsinki	44	27	22	7	29
Singapore	45	41	10	4	14
Zurich	46	18	20	15	35
Paris	46	18	35	1	36
Stockholm	47	19	34	0	34
Copenhagen	49	12	19	20	39
London	50	19	30	1	31
Madrid	51	15	30	4	34
Rome	56	20	23	0	23
Brussels	59	11	23	8	31
New York[b]	61	30	–	–	9
Athens	64	28	7	2	9
Glasgow	66	11	23	1	24
Melbourne	76	6	17	1	18
Dubai	77	7	16	0	16
Washington[b]	77	16	–	–	7
Chicago	88	6	5	1	6
Atlanta[b]	95	5	0	0	0

Note: [a] From ADB (2001); car mode here consists of 11 per cent private automobile, 18 per cent motorcycle or three-wheeler.
[b] From L. R. Brown (2001), early 1990s data.
Source: Gilbert and Perl (2007), unless indicated otherwise

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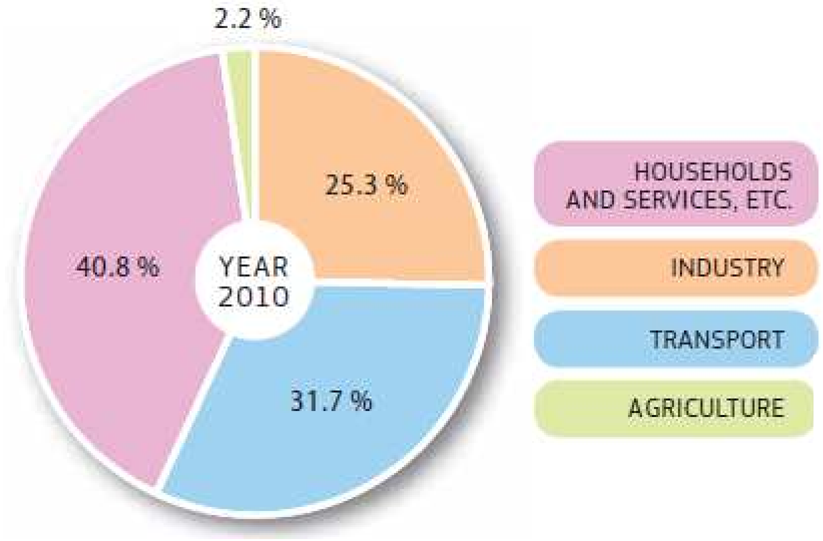
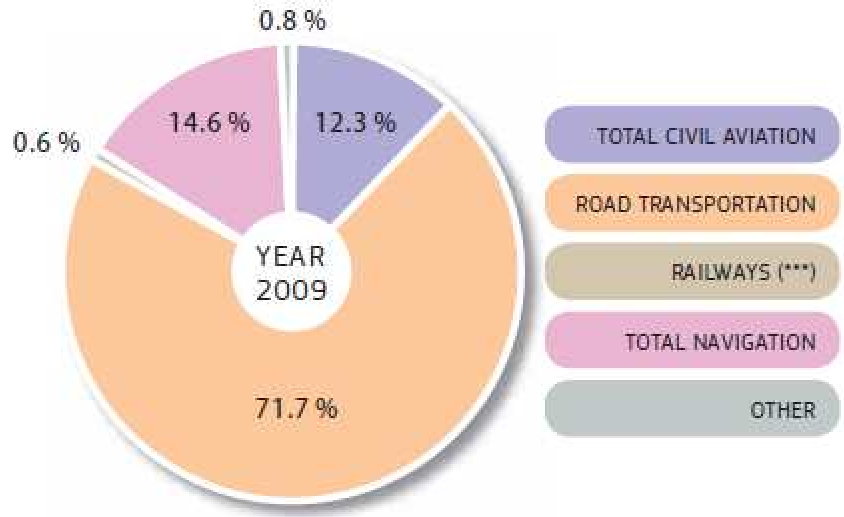


Europe 27, ~1100 Mtoe



@ Energy & Transport in figures 2010
http://ec.europa.eu/transport/facts-fundings/statistics/doc/2012/pocketbook2012.pdf

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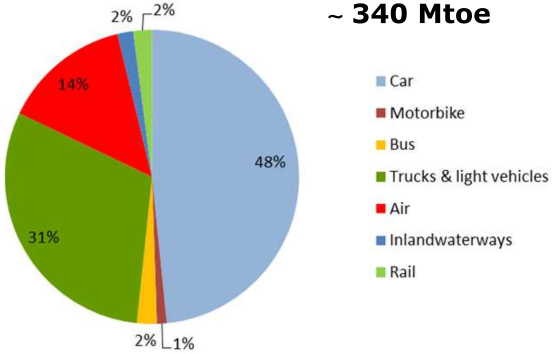
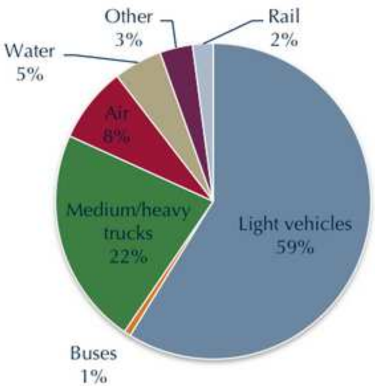
- Energy use by transport mode 2010

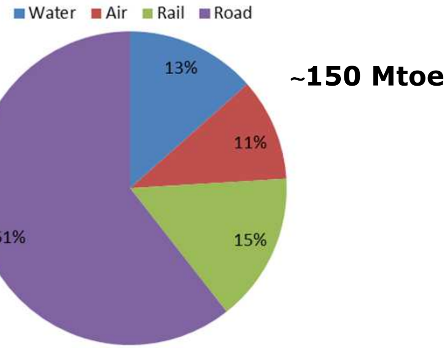


EEA – Energy consumption by transport mode in the EU-27, 2012

27 quadrillion BTU,
~ 680 Mtoe



U.S. Department of Energy. Transportation Energy Data Book, Table 2.5, 2011. http://cta.ornl.gov/data/chapter2.shtml



ERI – Energy Research Institute. China energy supply and demand projection in 2030, NDRC; 2005.

IEA – Key World Statistics 2012

VEHICLE STOCK

		EU-27	USA	JAPAN	CHINA	RUSSIA
		2010	2009	2010	2010	2010
Passenger cars stock	million	238.8	234 (*)	69.2 (*)	40.3	32.6
Motorization	cars / 1 000 persons	477	763	542	30	228
Commercial freight vehicles	million	34.09	10.97	6.22	13.69	5.41

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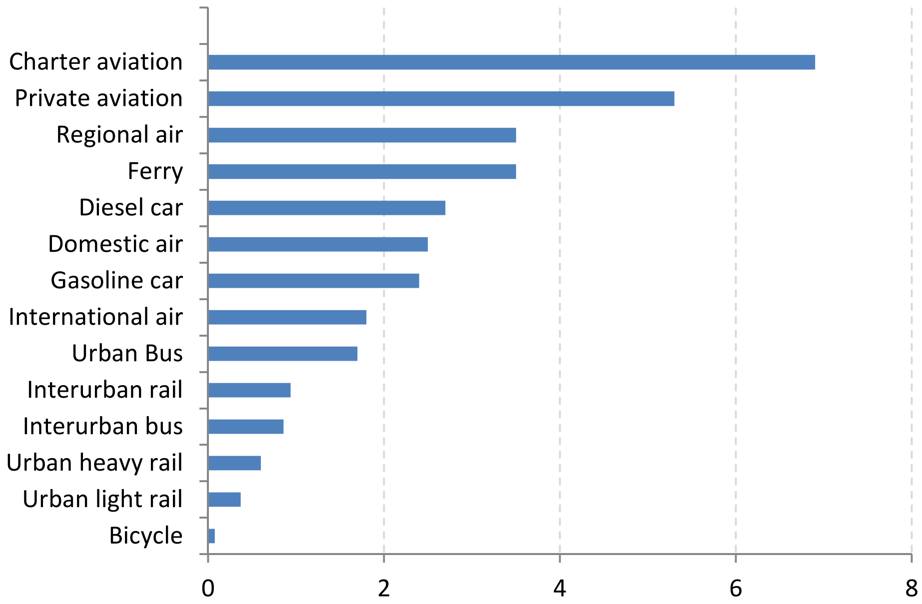
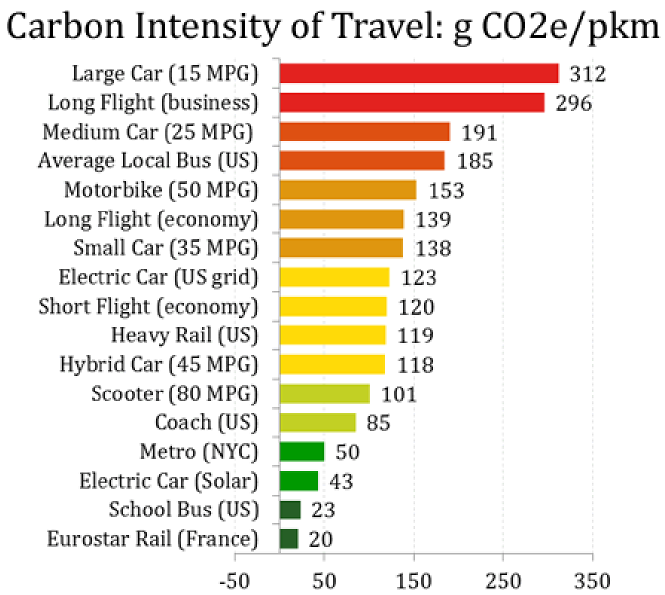
Typical energy consumption by mode

MJ/(p*km)

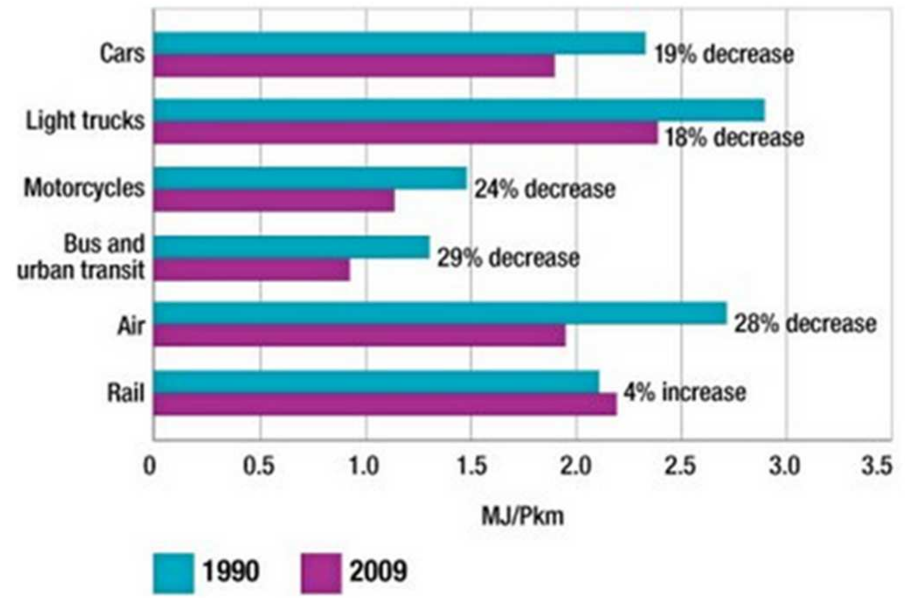


Australia, Lenz (1999)



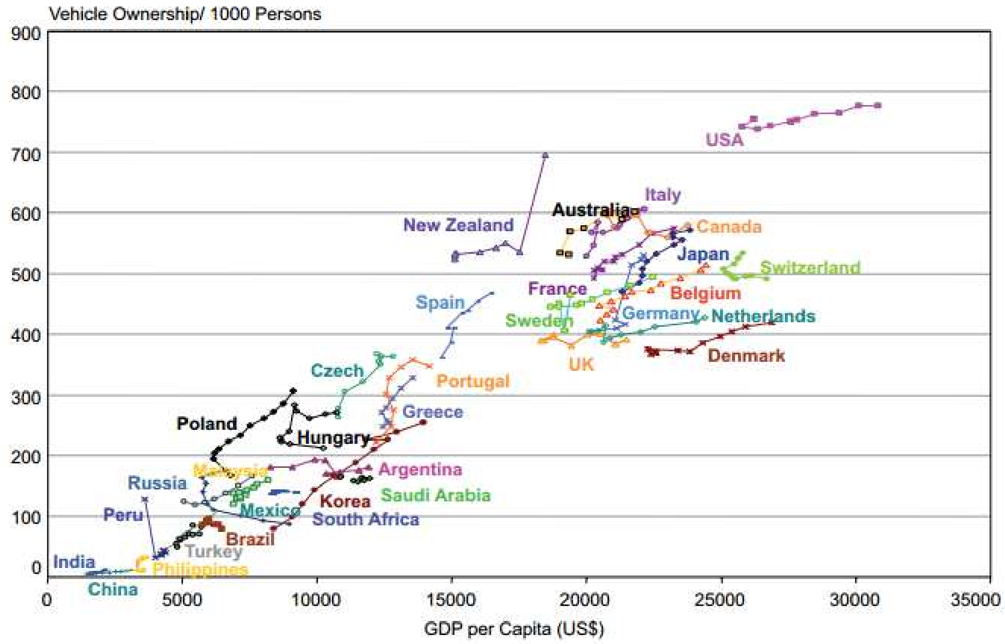
US, 2005, http://shrinkthatfootprint.com/shrink-your-travel-footprint

Typical energy consumption by mode

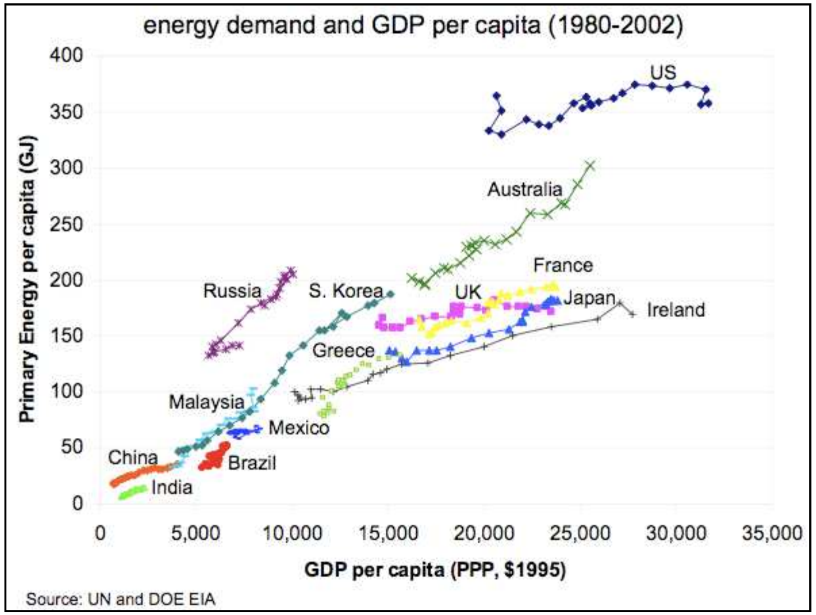


Natural Resources Canada, http://oee.nrcan.gc.ca/publications/statistics/trends11/chapter6.cfm?attr=0

- Trends…..GDP



Kahn Ribeiro, S., S. Kobayashi, M. Beuthe, J. Gasca, D. Greene, D. S. Lee, Y. Muromachi, P. J. Newton, S. Plotkin, D. Sperling, R. Wit, P. J. Zhou, 2007: Transport and its infrastructure. In Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [B. Metz, O.R. Davidson, P.R. Bosch, R. Dave, L.A. Meyer (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.



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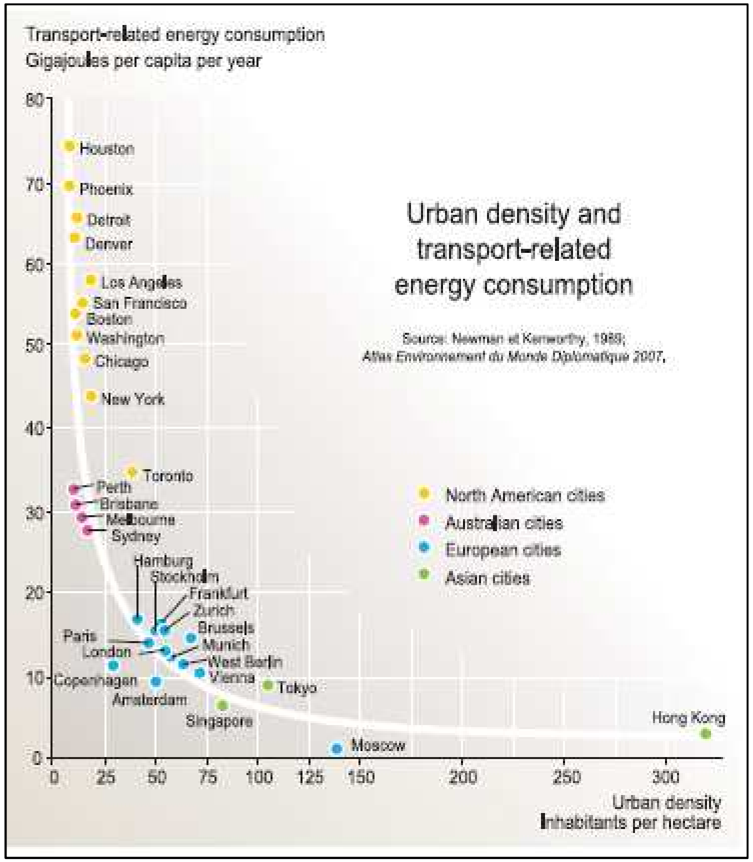
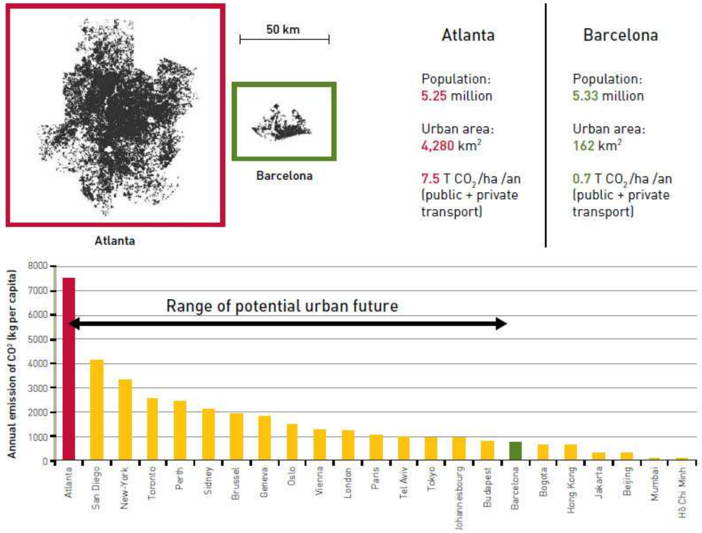
- Trends…..urban density





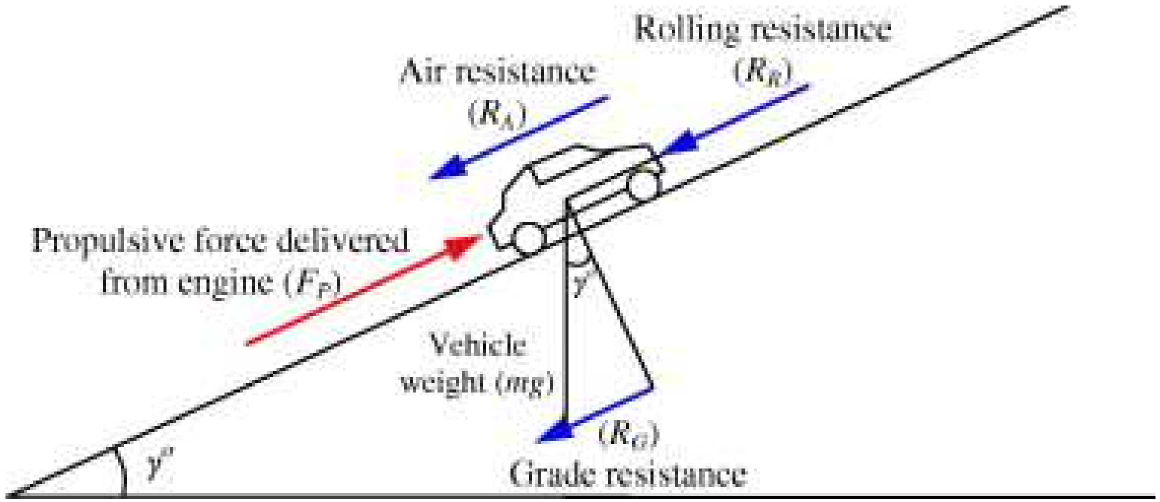
Global urban density	Low < 25 hab/ ha	Medium 50 – 100 hab / ha	High > 250 hab+/ ha
Modal distribution	MPT: 80% PT: 10% NMT: 10%	MPT: 50% PT: 25% NMT: 25%	MPT: 25% PT: 50% NMT:25 %
Automobile use (km / pers / yr)	> 10 000		< 5 000
Public transport use (trips / pers / an)	< 50		> 250
Petrol consumption for transport (MJ / pers / an)	> 55,000	35,000 – 20,000	< 15,000
Representative positions	North American and Australian cities	European cities	Asian cities

MPT: Motorised Public Transport; PT: Public Transport; NMT: Non Motorised Transport. Density: number of inhabitants and jobs per hectare of net urban surface (omitting green and water surfaces).

Source: Newman and Kenworthy, 1999.

Energy Management

Vehicle dynamics



Roling $$Rr = k_r(m+m_p)g \bullet \cos\gamma$$

Road gradient $$Fw = (m+m_p)g \bullet \sin\gamma$$

Aerodynamics $$Ra = 1/2 \bullet \rho C_d A_f v^2$$

Propultion $$Fp = (k_m \bullet m+m_p) \bullet dv/dt$$

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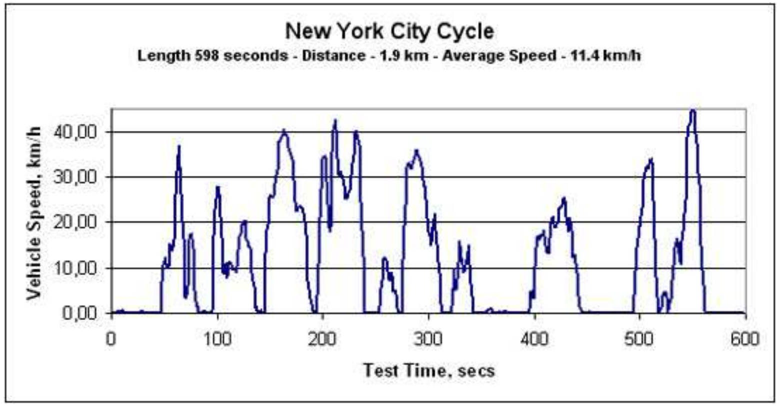
Energy Management

Vehicle dynamics



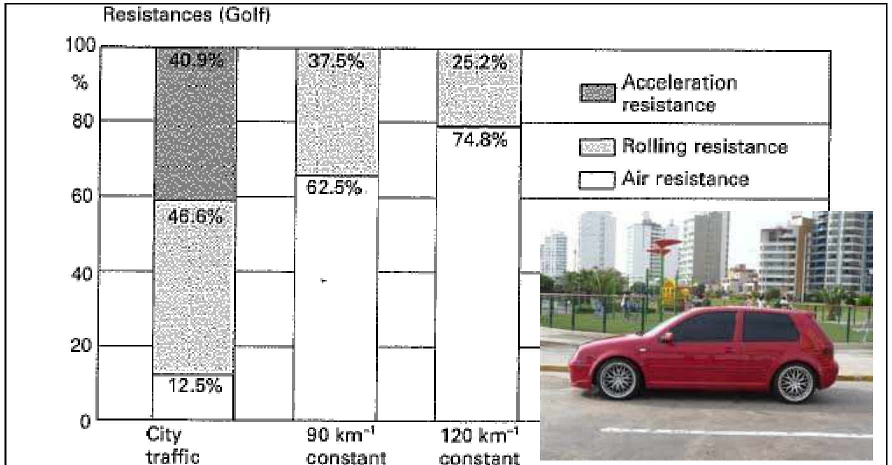
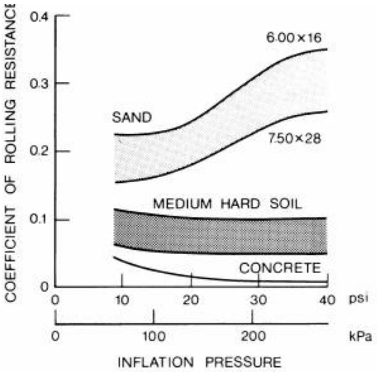


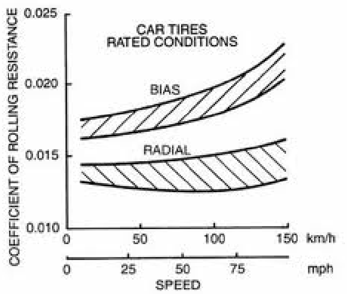
Fig. 2.32 In town and when the vehicle is travelling at low speeds on rural roads, fuel consumption is determined up to 40% by the rolling resistance, whereas at higher speeds the air drag is the determining factor see Section 2.1 and Section 2.2 in Ref. [3]). The figure shows a study carried out by VW on the Golf.

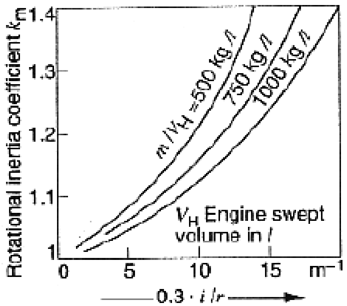
Contribution of Tire Rolling Resistance to Vehicle Fuel Economy Versus Speed
(Reprinted with permission from the Automotive Chassis: Engineering Principles, 2nd Edition, Reed Educational and Professional Publishing Ltd., 2001)

Roling	k_r
Aerodynamics	$C_d A_f$
Propultion	k_m

Vehicle dynamics



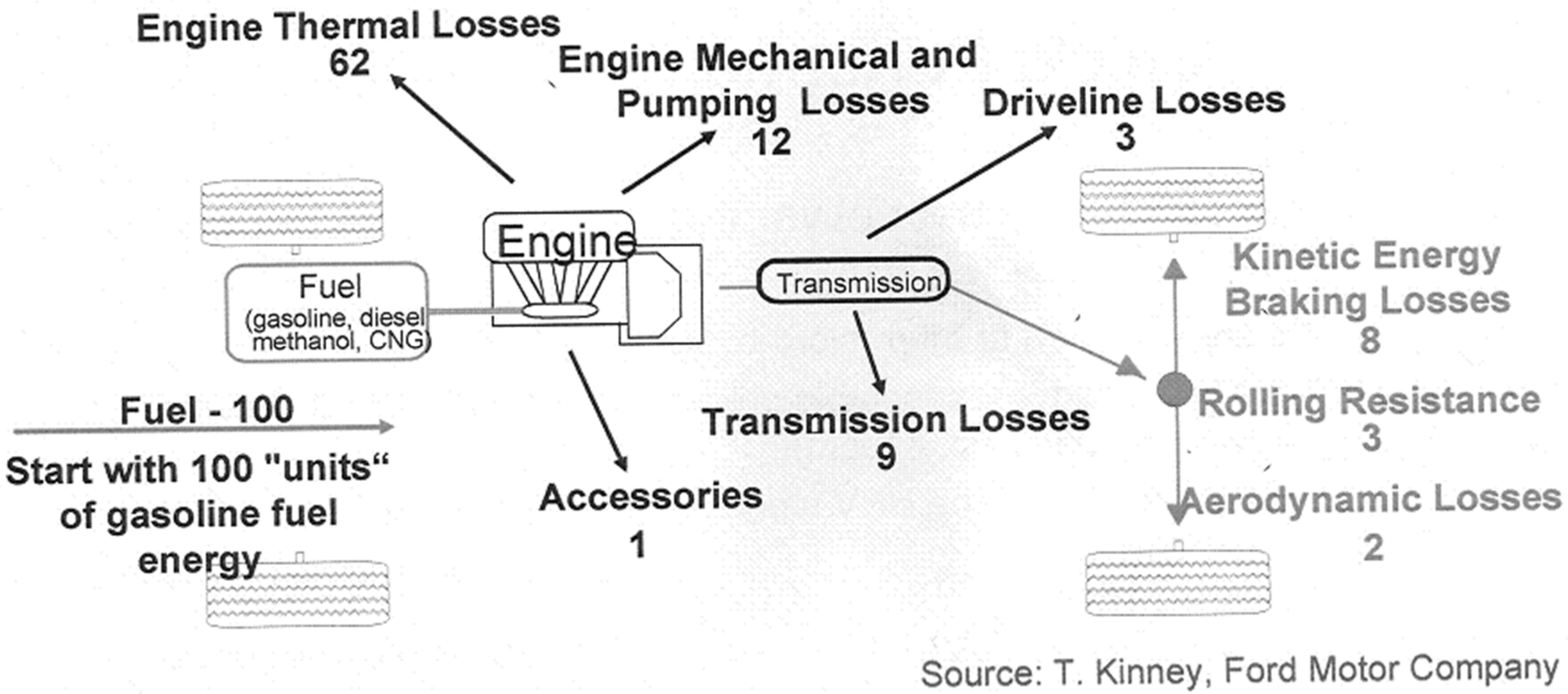




Roling	k_r	0.013	0.01
Aerodynamics	$C_d A_f$	0.35x1.91m^2	0.6x7m^2
Propultion	k_m	1.1	1.13

Energy Efficiency

Efficiency (~13% available energy for the motion)



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- Legislation

On 25 October 2012, the EU adopted the Directive 2012/27/EU on energy efficiency

'20-20-20' initiative for 2020,
saving of 20% of the Union's primary energy decrease 20% of greenhouse gas emissions include 20% of renewable energies in energy consumption.

Action plan:

- **120g CO_2/km by 2012**
- **European standard for rolling resistance-tire labelling**
- **Vehicle labelling**
- **Use of alternatives to car transport, such as public transport, non-motorised transport and teleworking**

Energy Efficiency Strategies

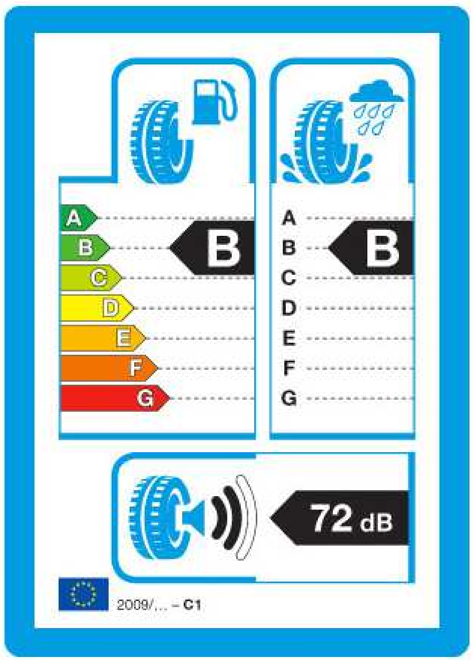
Info in labels for consumers

CO_2 and fuel

Energy Efficiency Strategies

Tire labels for consumers

blackcircles.com
the new way to new tyres



Fuel efficiency

- The energy lost when a tyre is rolling is expressed as 'rolling resistance'
- Lower rolling resistance reduces fuel consumption and CO2 emissions
- A is the highest performance tyre
- G is currently the least performing

wet grip

- Provides you with information on the tyre's grip on wet roads
- Tyres with excellent grip in the wet have shorter braking distances on wet roads
- A indicates the highest wet grip performance
- G indicates the lowest wet grip performance

Noise levels

- The tyre's exterior noise grading is expressed in decibels
- One black wave indicates the best noise level – at least 3dB below the future legal limit
- Three black waves indicate the weakest performance
- New legal noise limits will be introduced between 2012 and 2016

Specific policies road transport

Related to average fuel economy of the automobile fleet

1 Mandated improvement in average new car fleet fuel economy (CAFE standards)
2 Gas-guzzler purchase tax (to increase market demand for fuel-efficient vehicles)
3 Increase in gasoline tax (to increase market demand for fuel-efficient vehicles and to prevent the effective price of gasoline from falling due to more efficient use)
4 Enforcement of speed limits (improves actual on-road fuel economy)
5 Public education (benefits of engine maintenance, proper tyre pressure, less aggressive driving, no idling)

Related to air pollution emissions

6 Strengthen pollutant emission standards
7 Strengthen fuel quality standards (especially sulphur, cetane and aromatics content)
8 Improve enforcement of emission standards
9 Public education/exhortations

Related to total amount of travel, timing and modal split

10 Urban intensification (smart growth, infill)
11 Major public transportation infrastructure improvements
12 Incremental improvements to public transportation
13 Road pricing
14 Parking management (supply, cost, shared use, unbundling)
15 Pay-as-you-drive insurance
16 Promote car sharing
17 Promote car pooling
18 Promote telecommuting
19 Promote off-peak travel (via variable road pricing, for example)
20 Promote HOV (high-occupancy-vehicle) lanes
21 Improve walking/bicycling environment
22 Promote shift of freight to rail
23 Promote walking school buses
24 Provide student discounts for public transportation

Note: [a] This includes not only oil, but also – in the case of petroleum products made from the Canadian tar sands – the substantial amounts of natural gas that are used in upgrading the tar.

L. D. Danny Harvey

2010

Energy and the New Reality 1

Energy Efficiency and the Demand for Energy Services

Energy Efficiency Strategies

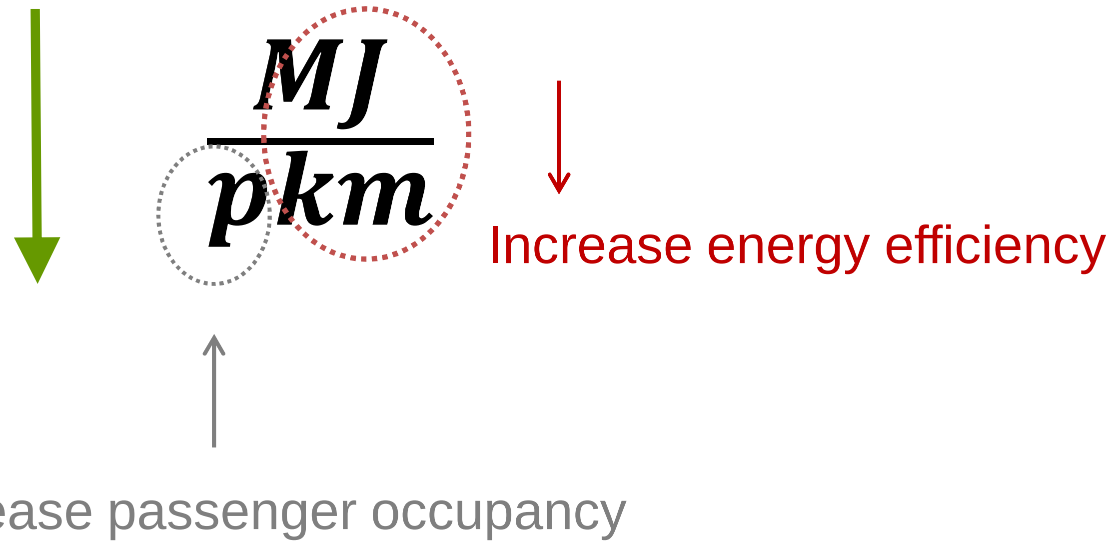
Table ES1: Progress in implementation of transport energy efficiency recommendations

Status/ Recommendation	Fully implemented	Implementation underway	Planning to Implement	Not implemented	Estimated energy saving
Fuel-efficient tyres		European Union, Canada, United States	Japan, Korea	Australia, New Zealand, Turkey	4-5%
Fuel efficiency standards: LDV	Japan, United States	Canada, European Union, Korea		New Zealand, Turkey Australia	20-30% reduction over the period 2005-2015/16
Fuel efficiency standards: HDV	Japan		European Union, United States	Australia, Canada, Korea, New Zealand, Turkey	12% reduction over the period 2006–2015 at Japanese target
Eco-driving programmes		Australia, Canada, European Union, Japan, Korea, New Zealand, United States		Turkey	5%-20% short term, circa 5-10% medium term

Source: Updated from IEA (2009b)

Energy Efficiency Strategies

Oil dependency and combustion emissions mitigation
(road passenger transportation)



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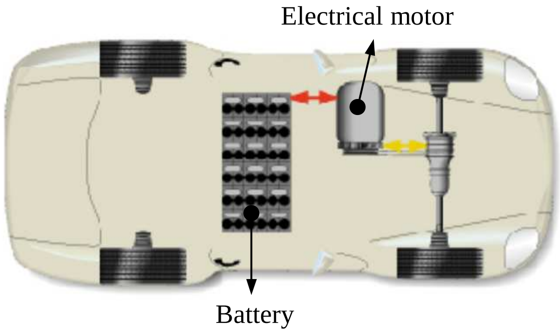
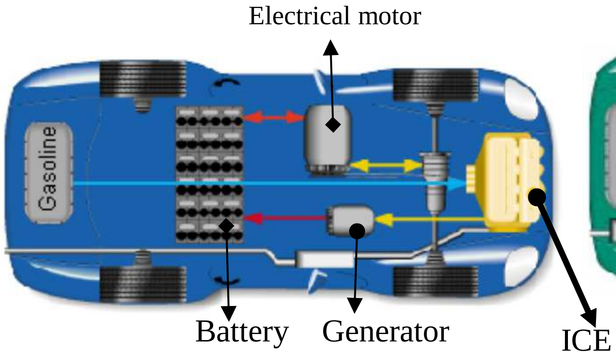
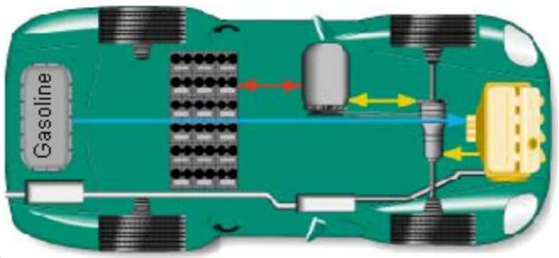


Pure electric (efic. 60-70%)

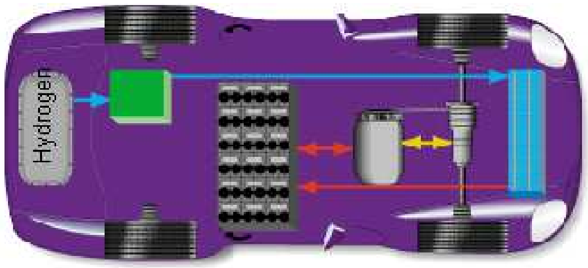
Hybrid (w/ or not plug-in capability)





Hybrids (efic. 20-30%)

Fuel cell (direct or hybrid)



Fuel cell (efic. 30-40%)

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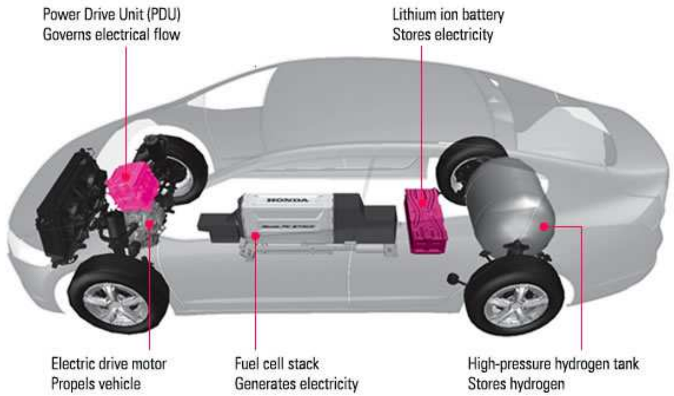
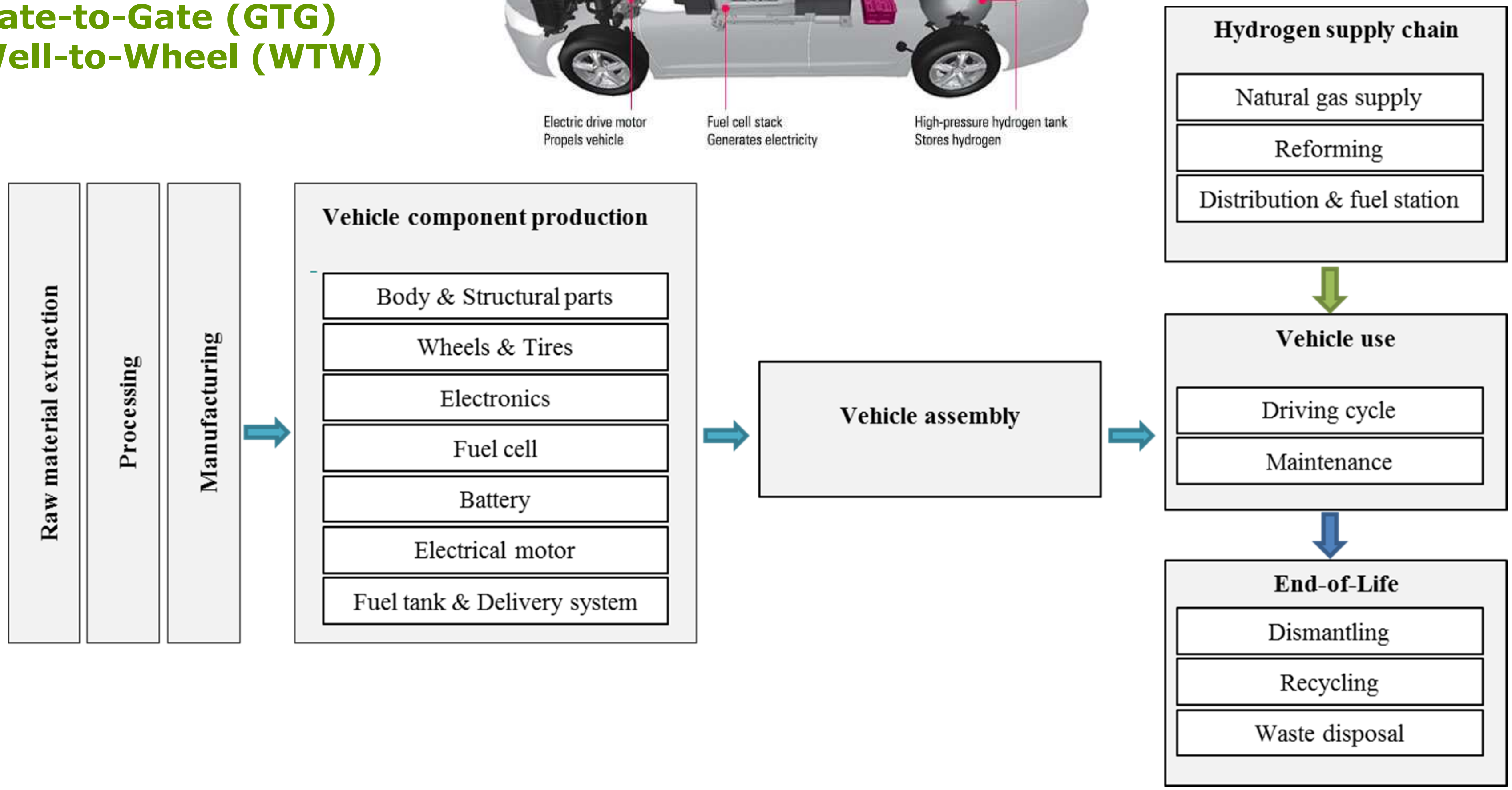
Life cycle notion

Cradle-to-Grave (CTG)
Cradle-to-Gate (CTG)
Cradle-to-Cradle (CTC)
Gate-to-Gate (GTG)
Well-to-Wheel (WTW)

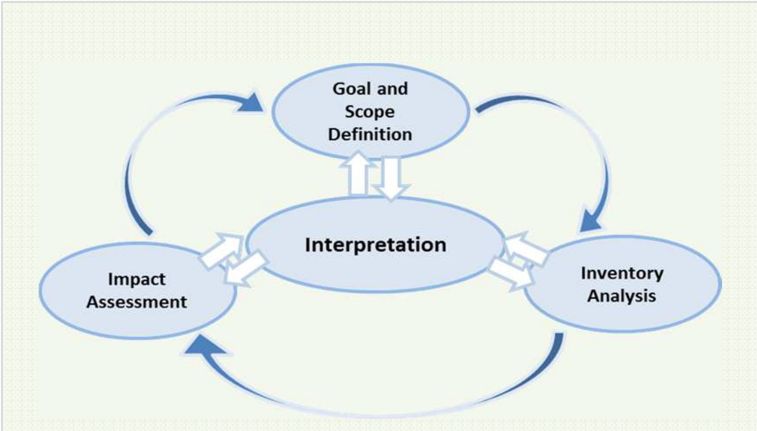




- **Ecodesign** **LCA – Life Cycle Analysis**

Methodology to assess environmental impacts associated with all the stages of a product's life from cradle-to-grave

- Raw material extraction
- Materials processing
- Manufacture
- Distribution
- Use
- Maintenance
- Disposal or recycling

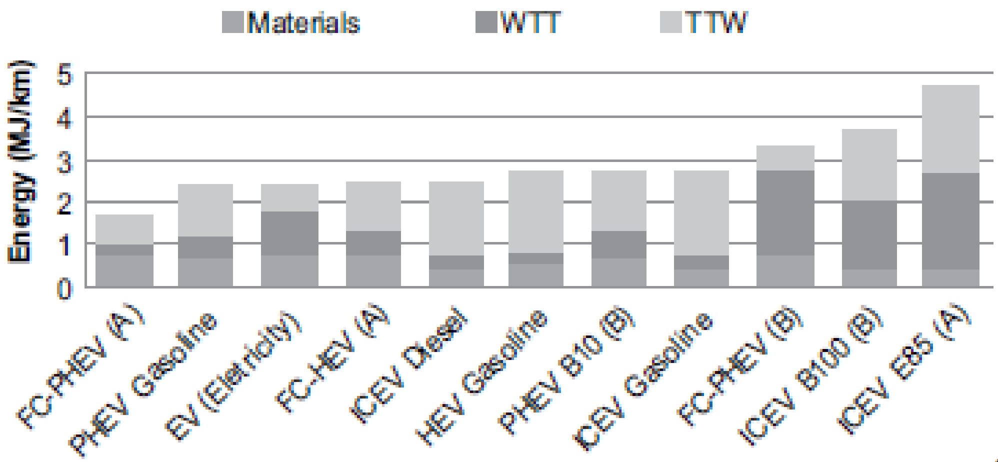


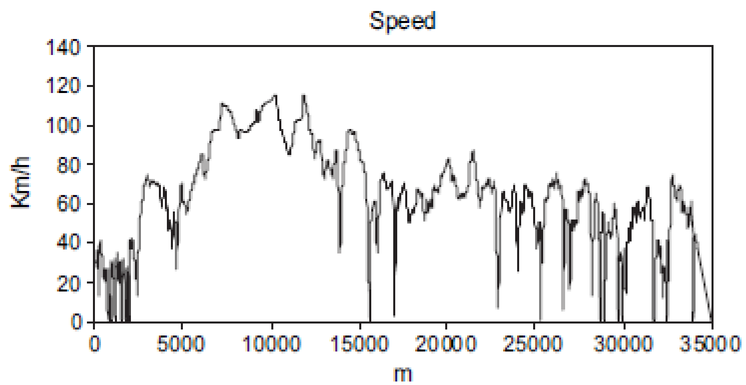
Steps as in ISO 14040:2006 and 14044:2006

Energy Management

Energy Efficiency Strategies

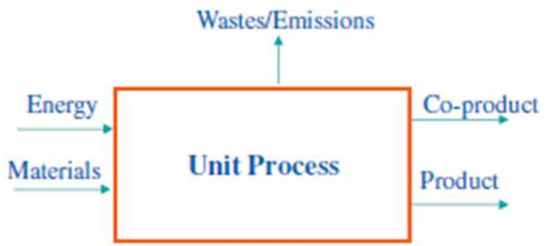
MJ life cycle split for light-duty vehicle 150000 km lifetime





Life Cycle – Inventory

Inputs-Outputs balance

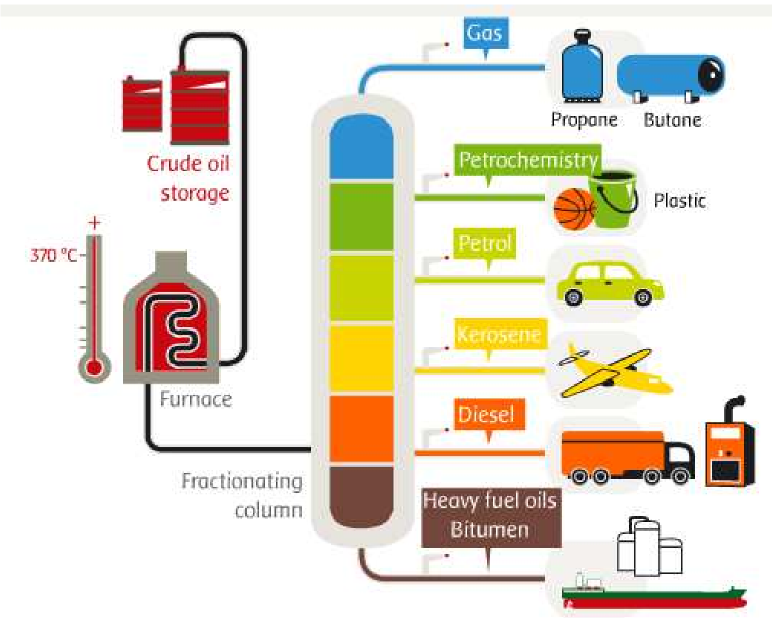


$$Energy = \sum Energy_{eachprocess} / FU$$

$$CO_2 = \sum CO_{2eachprocess} / FU$$

FU – Functional Unit e.g. MJ of final product
kg of final product
passenger.km
km

Life Cycle – Goal and scope definition



Tools/Software

http://lca.jrc.ec.europa.eu/lcainfohub/toolList.vm

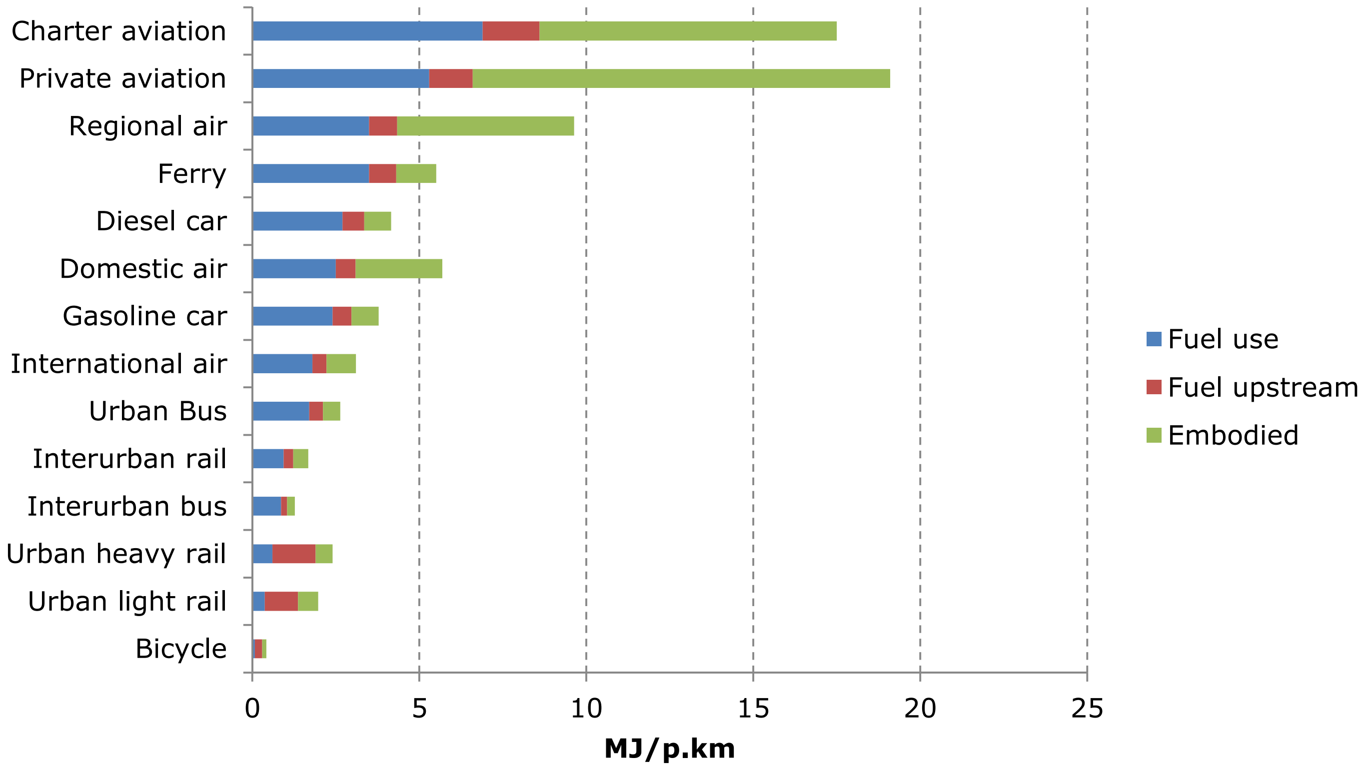
Generic

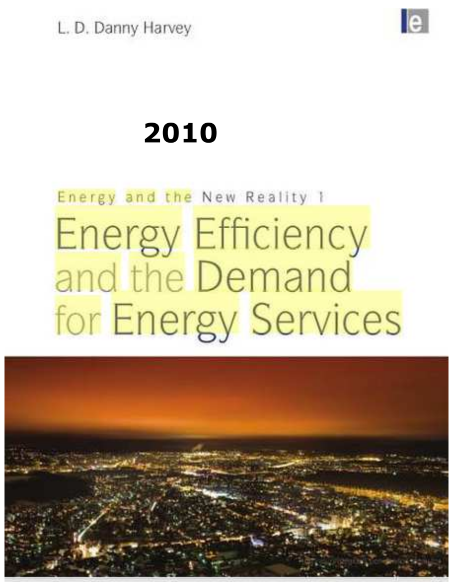
Boustead	www.boustead-consulting.co.uk
Eco-it	www.pre.nl
Ecopro	www.sinum.com
Ecoscan	www.ind.tno.nl
Euklid	www.ivv.fhg.de
KCL Eco	www.kcl.fi/eco
Gabi	www.gabi-software.com
LCAit	www.ekologik.cit.chalmers.se
Miet	www.leidenuniv.nl/cml/ssp/software
Pems	www.piranet.com/pack/lca_software.htm
SimaPro	www.pre.nl
Team	www.ecobilan.com
Wisard	www.pwcglobal.com
Umberto	www.umberto.de

Car specific

GEMIS	http://www.oeko.de/service/gemis/en/material.htm
GREET	http://greet.es.anl.gov/
LEM	http://www.its.ucdavis.edu/
Optiresource	http://www.optiresource.org

Typical energy consumption by mode in book





Exercises (Functional Unit)

Compare biofuels with diesel/gasoline

Provide biodiesel valid FU?

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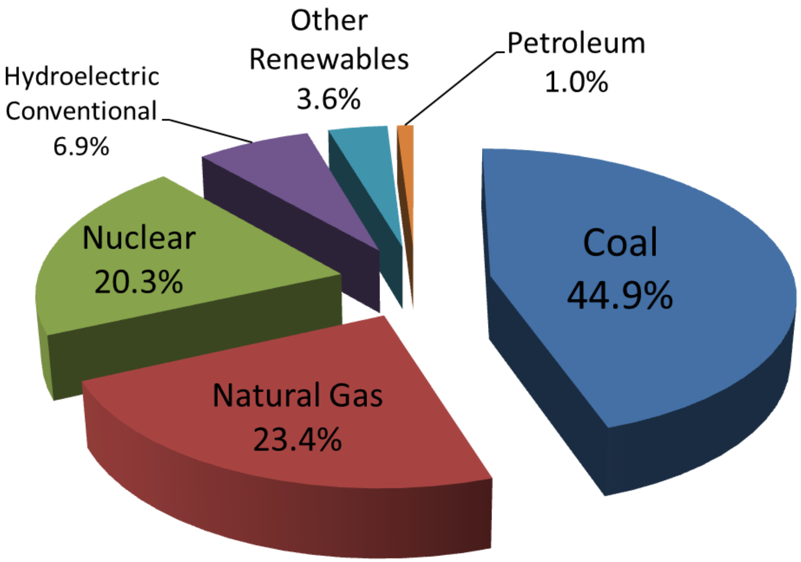
Exercises (Energy efficiency)

What is the average energy consumption of a ICE car in a trip of 2 km with 2 occupants, 20 kg of cargo, average 2% road grade, average 50 km/h, average 0.5 m/s^2 acceleration?

Exercises (Energy efficiency)

What is the WTW energy consumption of an electric vehicle, in a country with electricity mix as follows?



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Exercises (Energy efficiency)

What is the energy consumption of a vehicle in MJ/km if it has the following fuel consumptions? And CO2 emission?

1km/l diesel

100 mpg gasoline

5 l/100km LPG

Energy Management– Energy in Transports
1st semester 2013/2014

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