Ciências ULisboa

Faculdade
de Ciências
da Universidade
de Lisboa

DISCIPLINA MIEA 2018

Mobilidade Sustentável

Energy and emissions

Home ⟷ Work/ University

on a regular basis

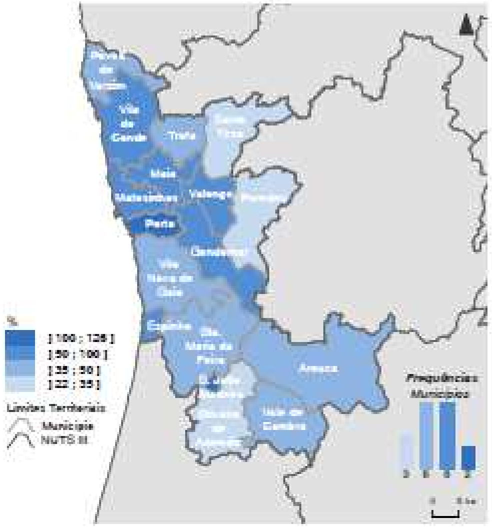
Commuting by motorized or soft modes

Emissions

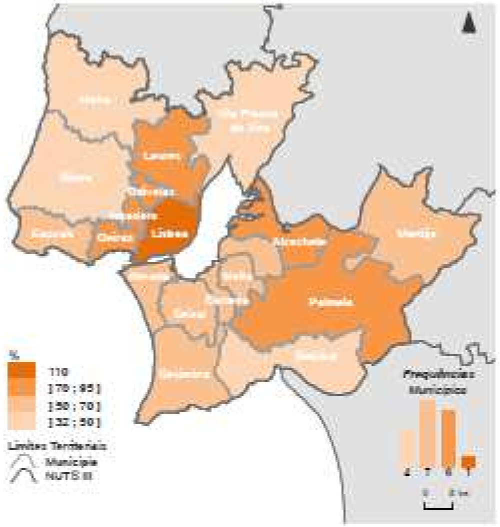
Energy

Lisbon versus Porto (metropolitan areas)

Entradas nos municípios da AM Porto



Entradas nos municípios da AM Lisboa



sustainable mobility????

Indicators

Indicator	Weight	Definition
CO_2	5	emissions from commuting in kg/capita/year (non-biogenic)
PM2.5	10	Annual hourly arithmetic average
NOx	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)

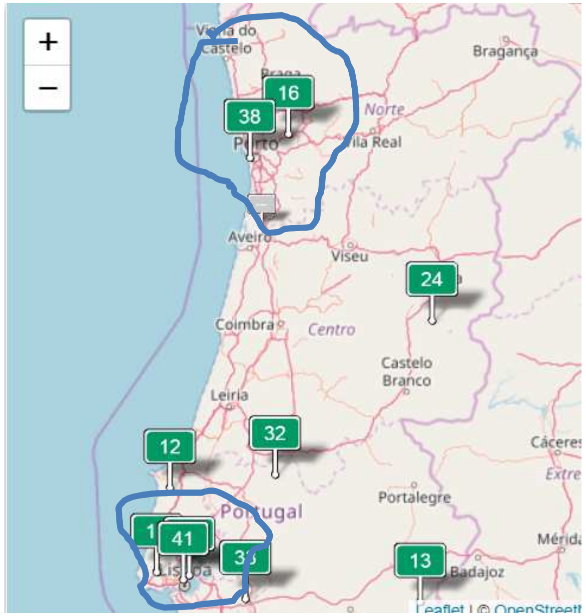
CO_2 7.5- 0 (ton/capita/year)

NO_x 200- 0 (µg/m^3)

O_3 240-0 (µg/m^3)

Energy 100-0 (%)

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

Fleet impacts

AQS – QUALAR data (downloads section)

Lisboa Entrecampos Urban Traffic

Data	Dióxido de Enxofre	Partículas < 10 µm	Ozono	Dióxido de Azoto	Óxidos de Azoto	Monóxido de Carbono	Benzeno	Monóxido de Azoto	Partículas < 2.5 µm
(Hora UTC)	µg/m3	µg/m3	µg/m3	µg/m3	µg/m3	mg/m3	µg/m3	µg/m3	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	

Fleet impacts

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/m3	PM10	O_3	NOx
Maia D.Manuel II-Vermoim	14.7	48.1*	17.9
Matosinhos João Gomes Laranjo-S.Hora	20.7	42.8*	30.8
Porto Francisco Sá Carneiro-Campanha	19	39.6*	54
Average	18.1	43.5*	34.2

*nearest air quality monitoring station

What is sustainable mobility?

Comparing transport systems??

Sustainable mobility indicators

What is sustainable mobility?

$$I_{\text{sust mob}} = I_{CO2} + I_{NOx} + I_{O3} + I_{Energy}$$

I_{CO2}

I_{NOx}

I_{O3}

I_{Energy}

Lisboa	CO2	4.597679
	PM10	8.45
	NOx	7.92
	O3	8.166667
	Energy	1.205949
	Total	**30.34029**
Porto	CO2	4.597978
	PM10	9.419048
	NOx	8.288333
	O3	8.1875
	Energy	0.8997
	Total	**31.39256**

What is sustainable mobility?

Comparing transport systems??

31.39

30.34

And adding:

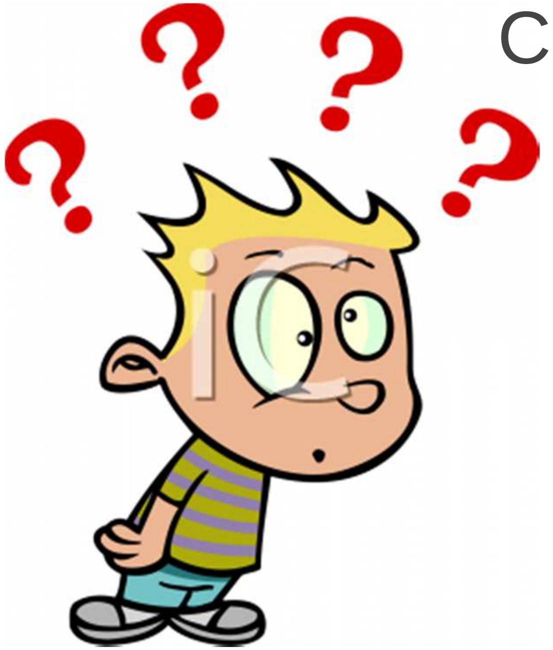
- **embodied energy and emissions of vehicle’s materials????**
- **energy production for transport upstream impacts????**

Global impacts

$$I_{sust\ mob} = I_{CO2} + I_{NOx} + I_{O3} + I_{Energy}$$

Carbon footprint

Global Warming potential
Impact category of LCA



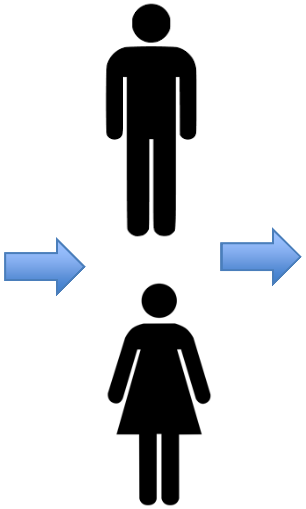
Global

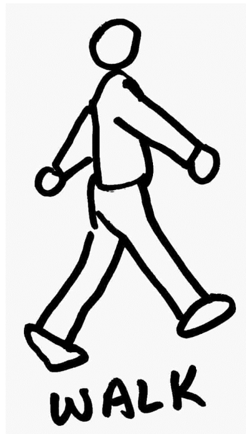
CO_2 equivalent or GHG

Fuel origin

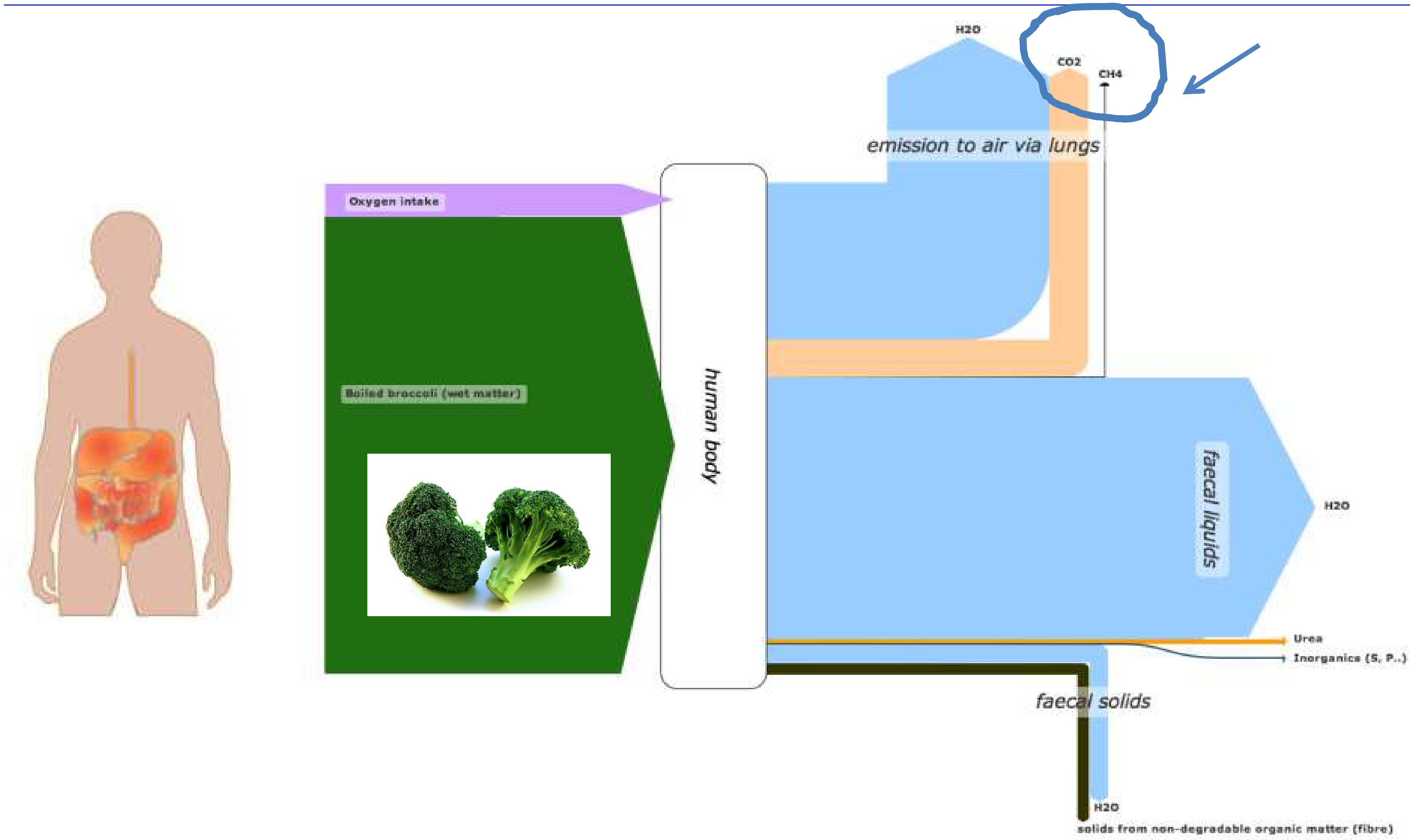
Food life cycle- Well-to-person

Energy use: person-to-wheels / person-to-legs



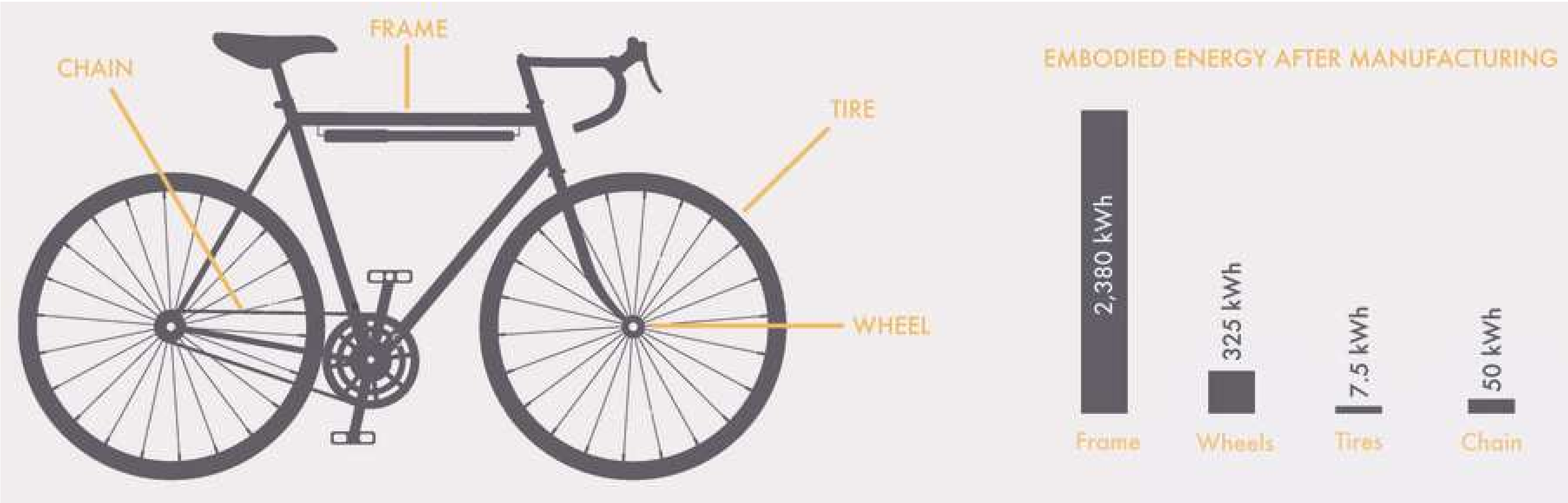


LIFE CYCLE


H2O
CO2
CH4
emission to air via lungs
Oxygen intake
Boiled broccoli (wet matter)
human body
faecal liquids
H2O
Urea
Inorganics (S, P..)
faecal solids
H2O
solids from non-degradable organic matter (fibre)

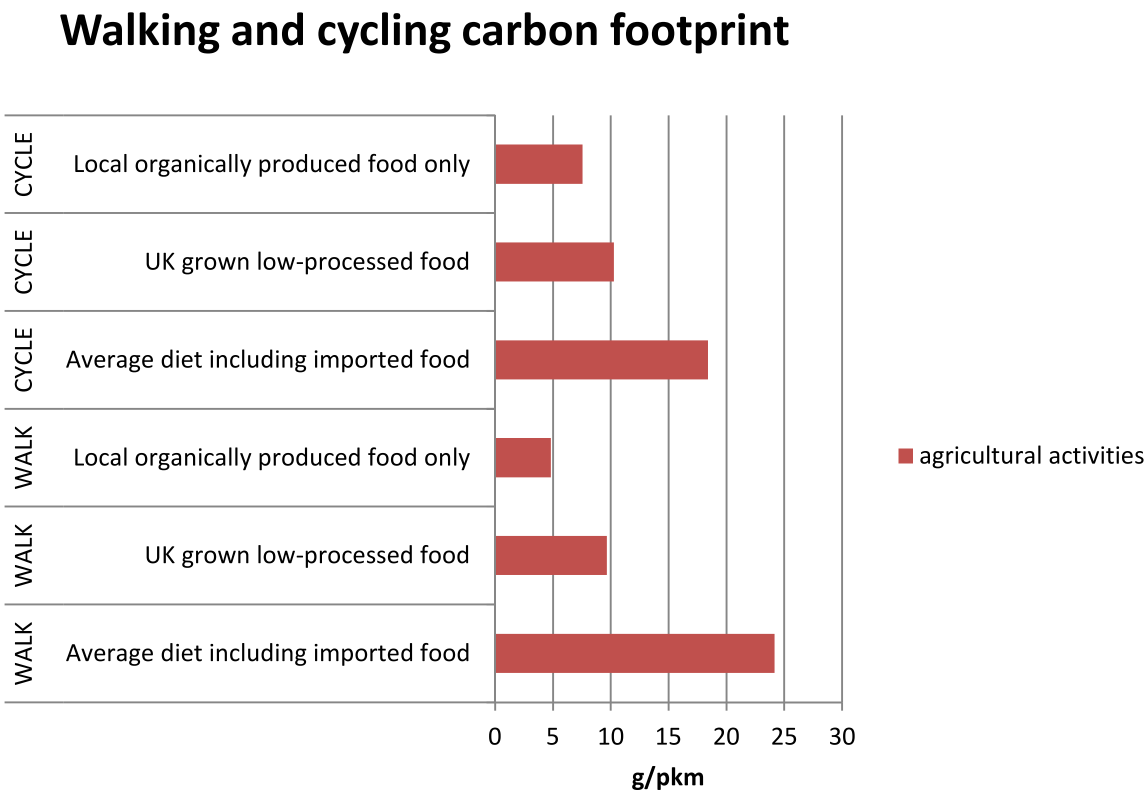
Manufacturing….materials embodied energy & emissions….

http://www.designlife-cycle.com/bicycle/



materials life cycle- Manufacturing

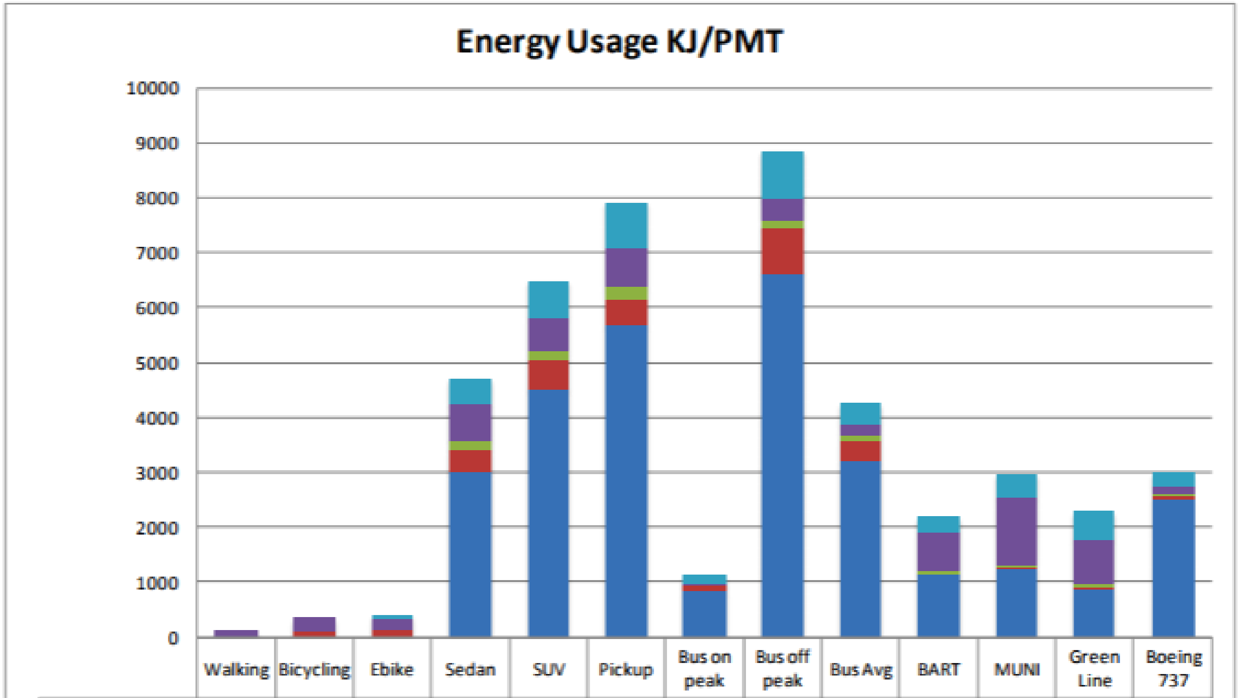
CO_2 emissions g/pkm



CO_2 emissions g/pkm





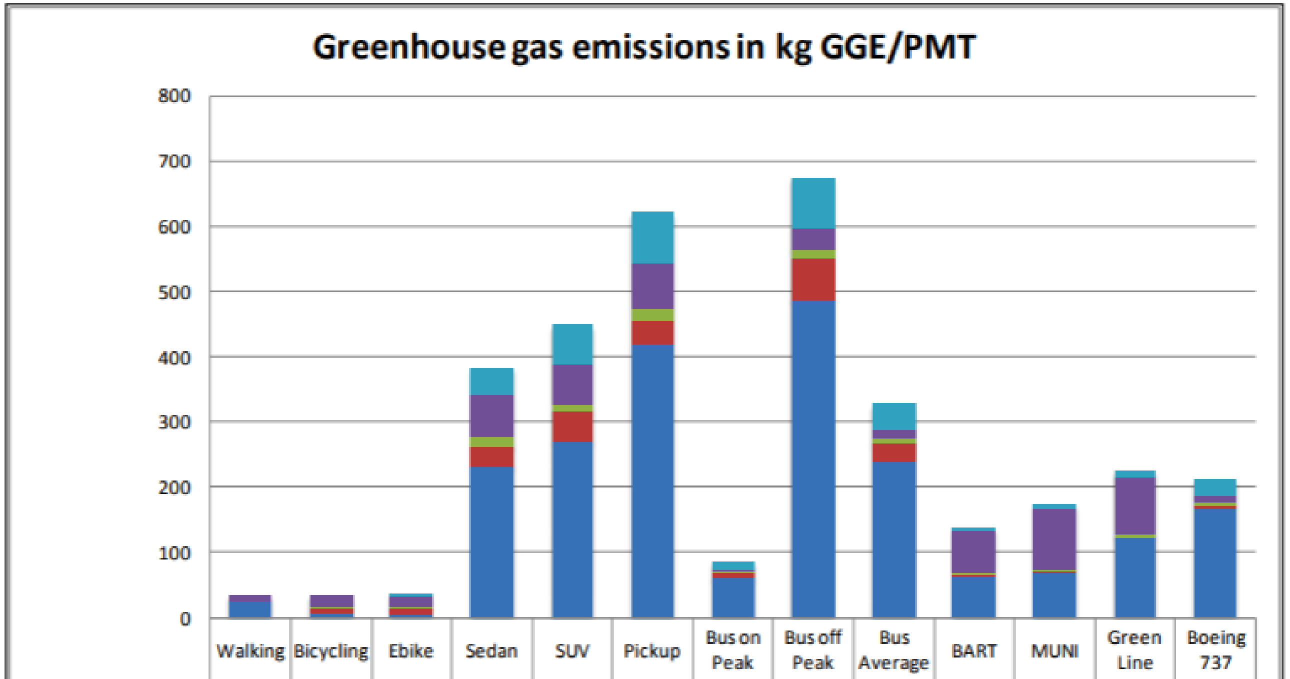



	Walking	Bicycling	Ebike	Sedan	SUV	Pickup	Bus on peak	Bus off peak	Bus Avg	BART	MUNI	Green Line	Boeing 737
Total	102	319	356	4694	6474	7914	1108	8837	4260	2187	2970	2270	2996
Fuel Production	0	0	2	430	640	810	110	840	400	274	418	487	250
Infrastructure	102	204	204	667	607	728	51	406	189	700	1233	829	119
Maintenance	0	9	9	184	180	208	18	144	68	41	51	54	56
Manufacturing	0	106	141	413	547	468	101	827	393	37	38	21	49
Operation	0	0	0	3000	4500	5700	828	6620	3210	1136	1230	879	2522

Figure 1: Energy input per PMT for commuter transport options

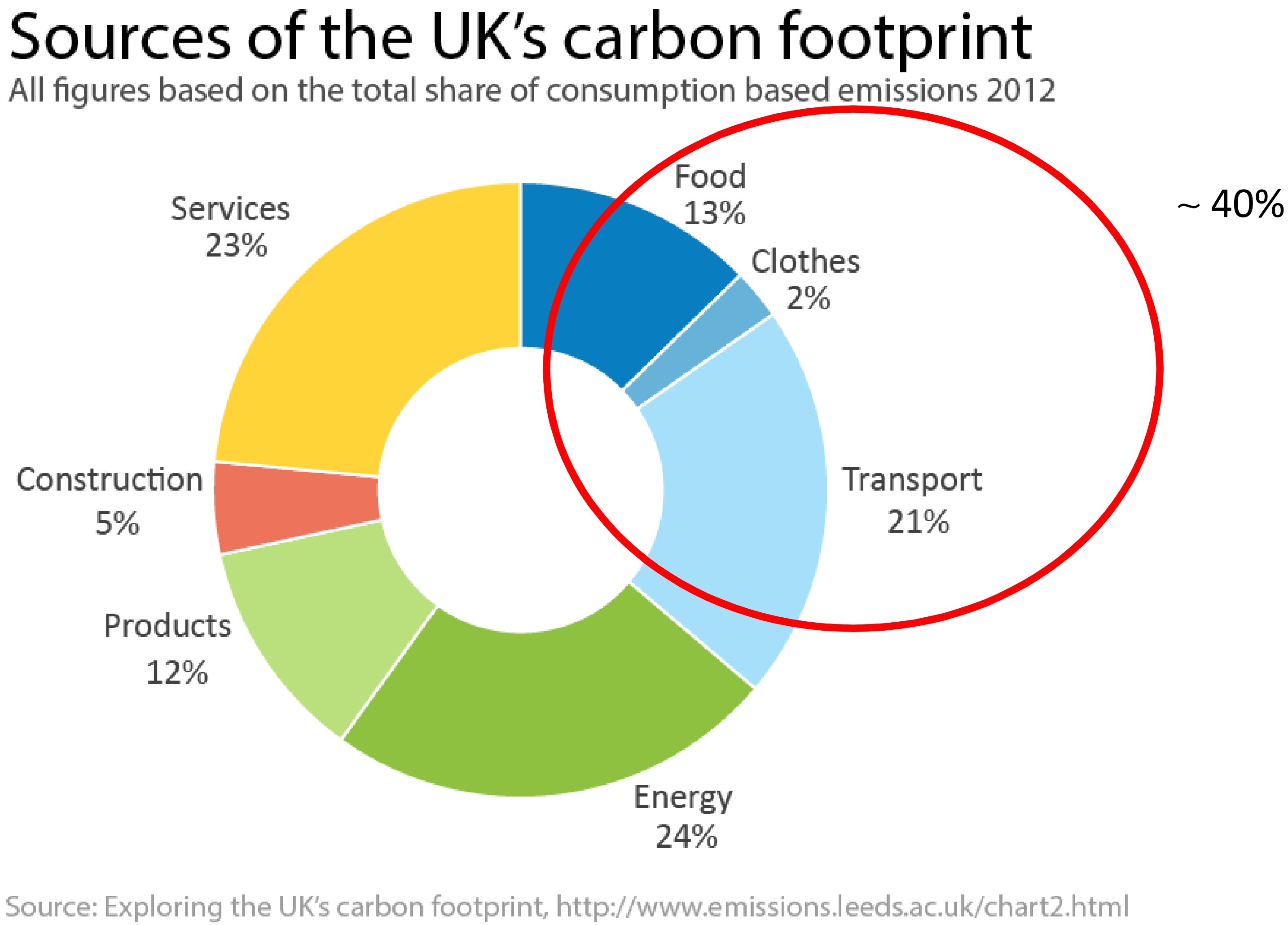
Shreya Dave. Life Cycle Assessment of Transportation Options for Commuters. Master thesis. Massachusetts Institute of Technology (MIT) February 2010

CO_2 emissions g/pkm



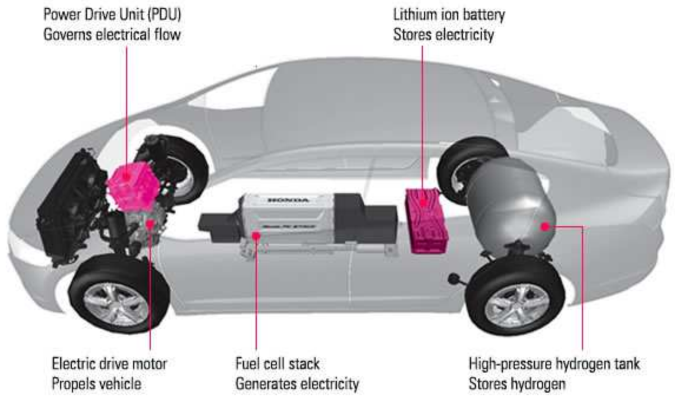
	Walking	Bicycling	Ebike	Sedan	SUV	Pickup	Bus on Peak	Bus off Peak	Bus Average	BART	MUNI	Green Line	Boeing 737
Total	33	33	33	382	446	619	85	674	326	136	173	224	210
Fuel Production	0	0	0.33	39	58	74	10	77	36	3	4	8	23
Infrastructure	9	17	17	65	59	71	4	34	16	64	94	87	11
Maintenance	0	1	1	15	14	17	1	12	6	2	4	4	4
Manufacturing	0	8	11	34	45	38	8	66	31	2	2	1	4
Operation	24	7	4	230	270	420	61	486	237	64	69	123	168

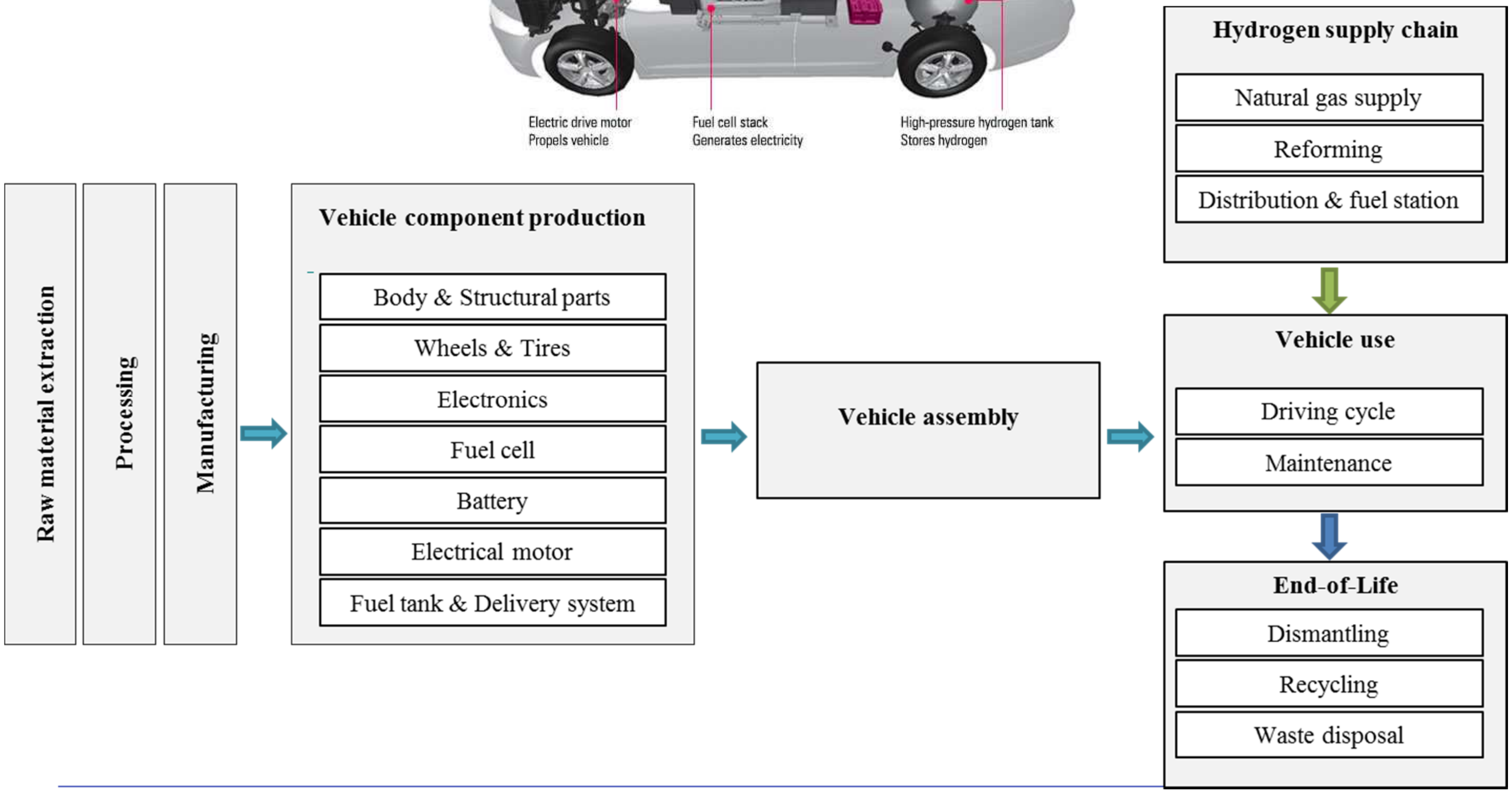
Shreya Dave. Life Cycle Assessment of Transportation Options for Commuters. Master thesis. Massachusetts Institute of Technology (MIT) February 2010


Sources of the UK's carbon footprint
All figures based on the total share of consumption based emissions 2012
Food
13%
Clothes
2%
Transport
21%
Energy
24%
Products
12%
Construction
5%
Services
23%
~ 40%
Source: Exploring the UK's carbon footprint, http://www.emissions.leeds.ac.uk/chart2.html

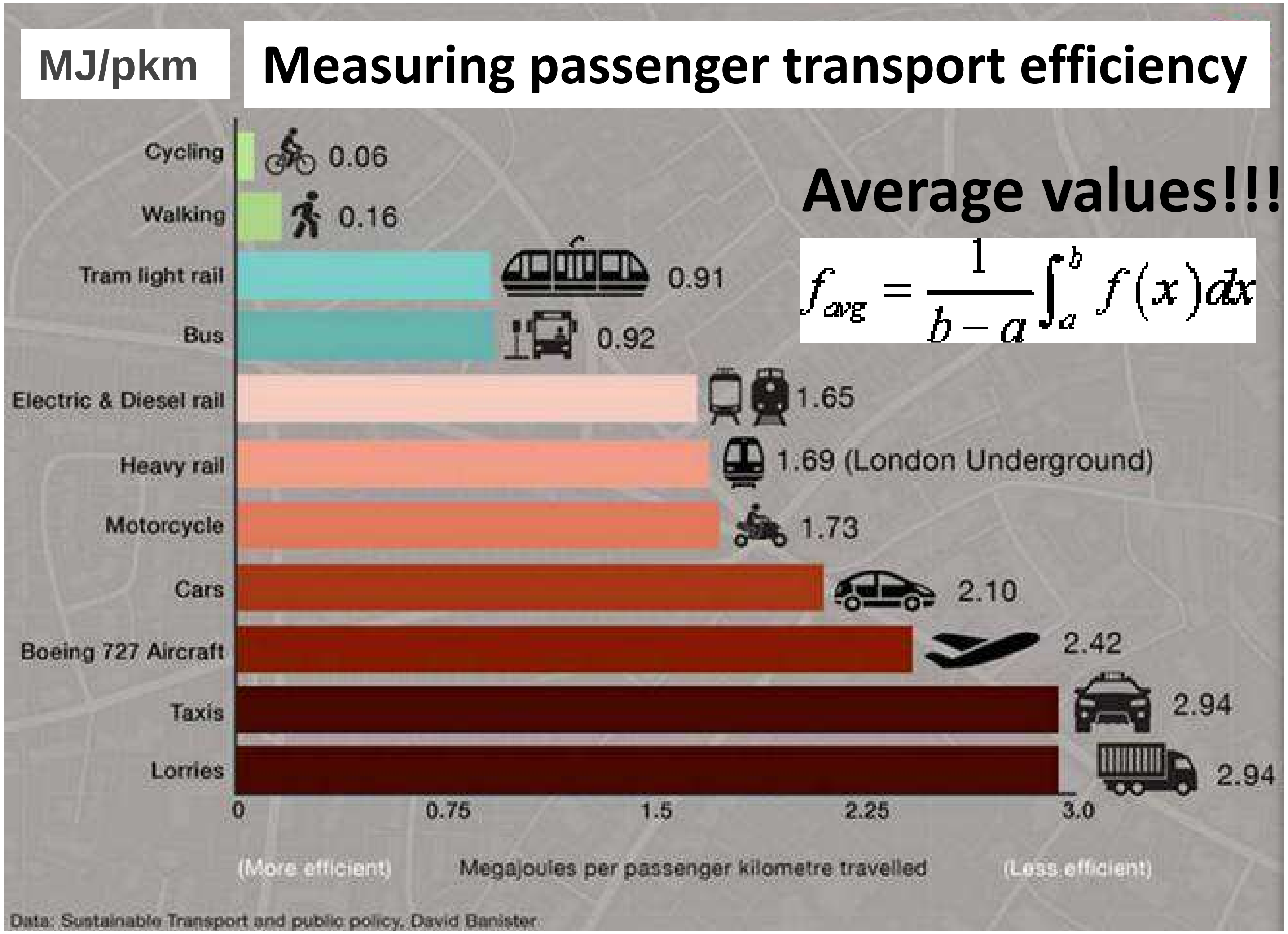
Total energy consumption

Life cycle notion





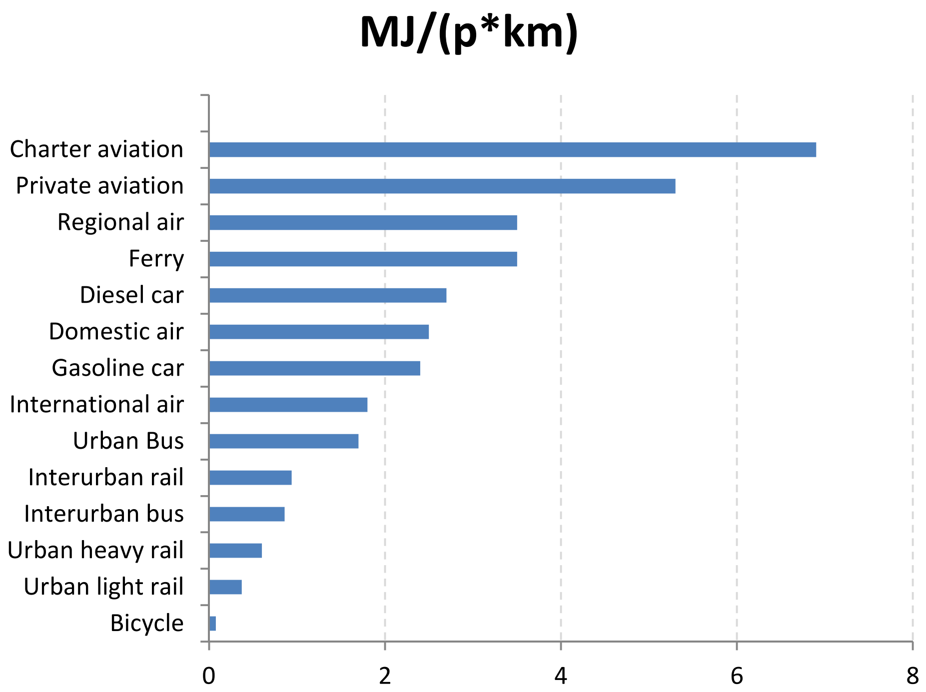
Life cycle



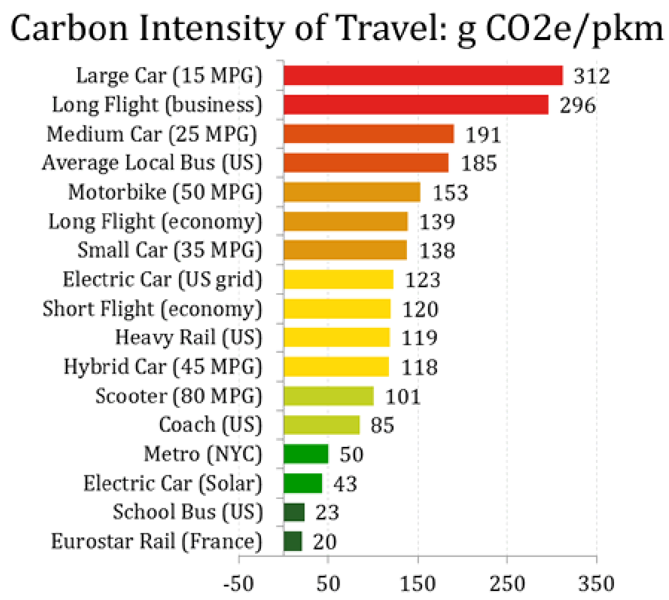
Average values!!!!!

$$f_{avg} = \frac{1}{b-a}\int_a^b f(x)\,dx$$

Typical energy consumption by mode



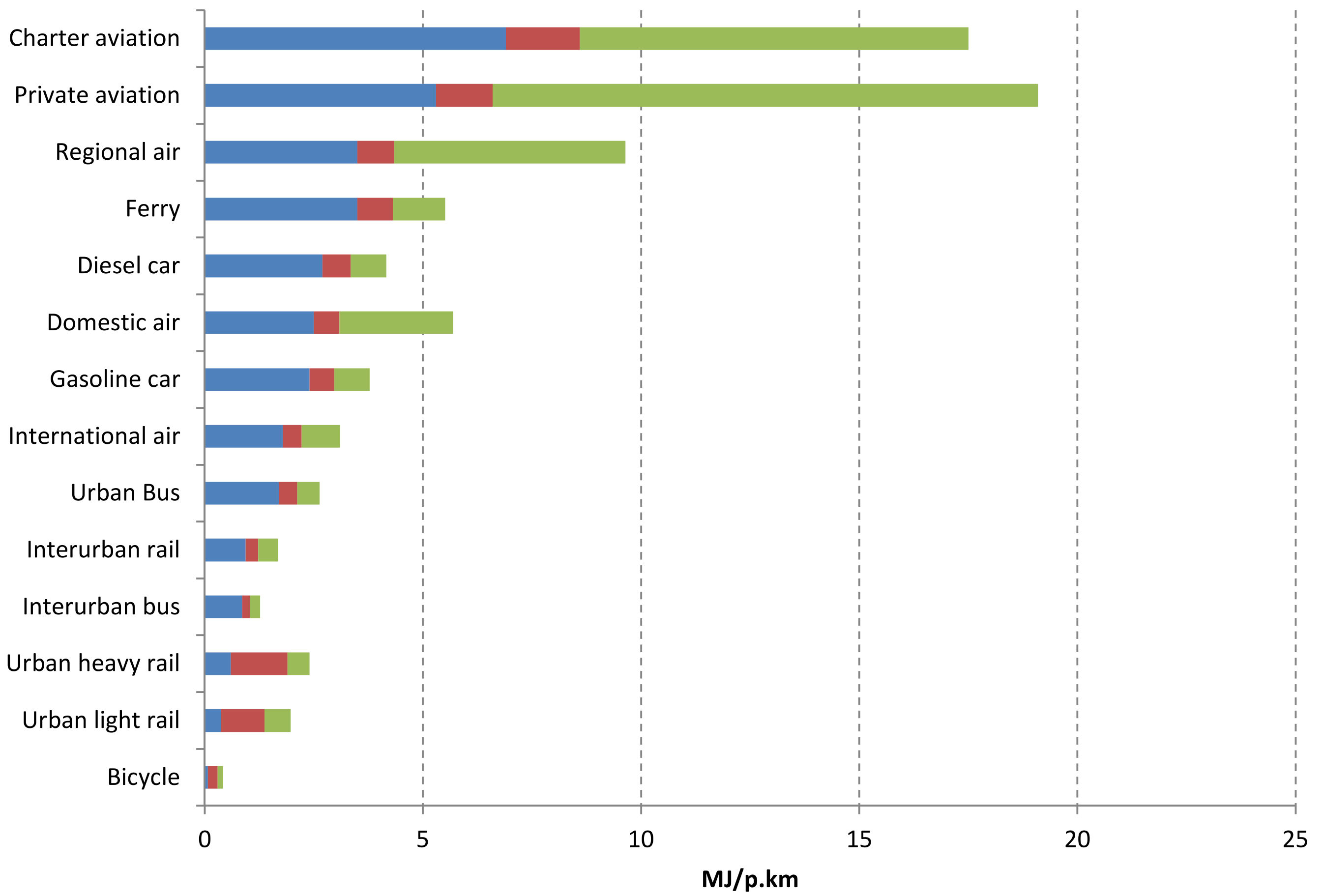
Australia, Lenz (1999)



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

L. D. Danny Harvey

Typical energy consumption by mode in book



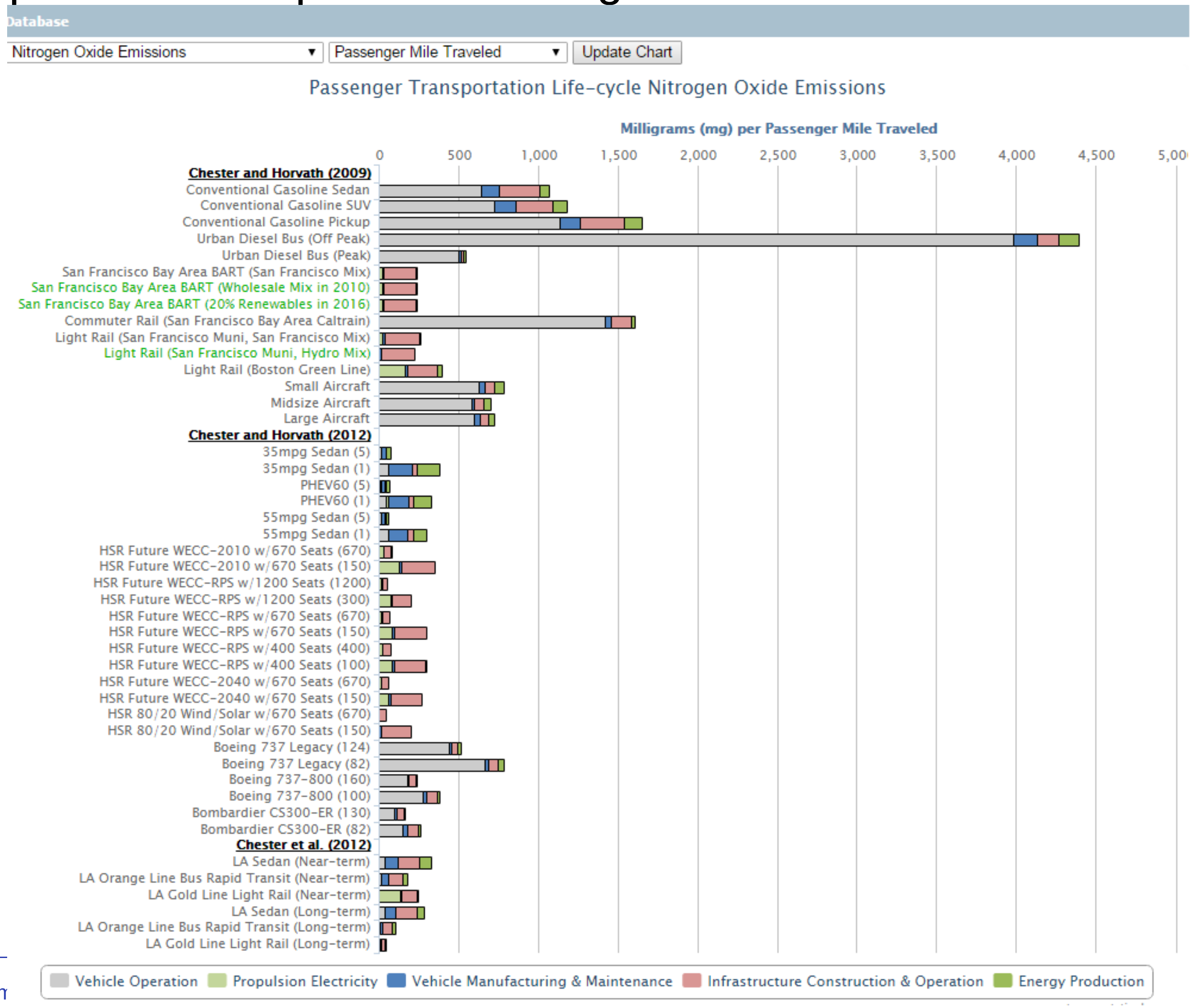
2010

Energy and the New Reality 1

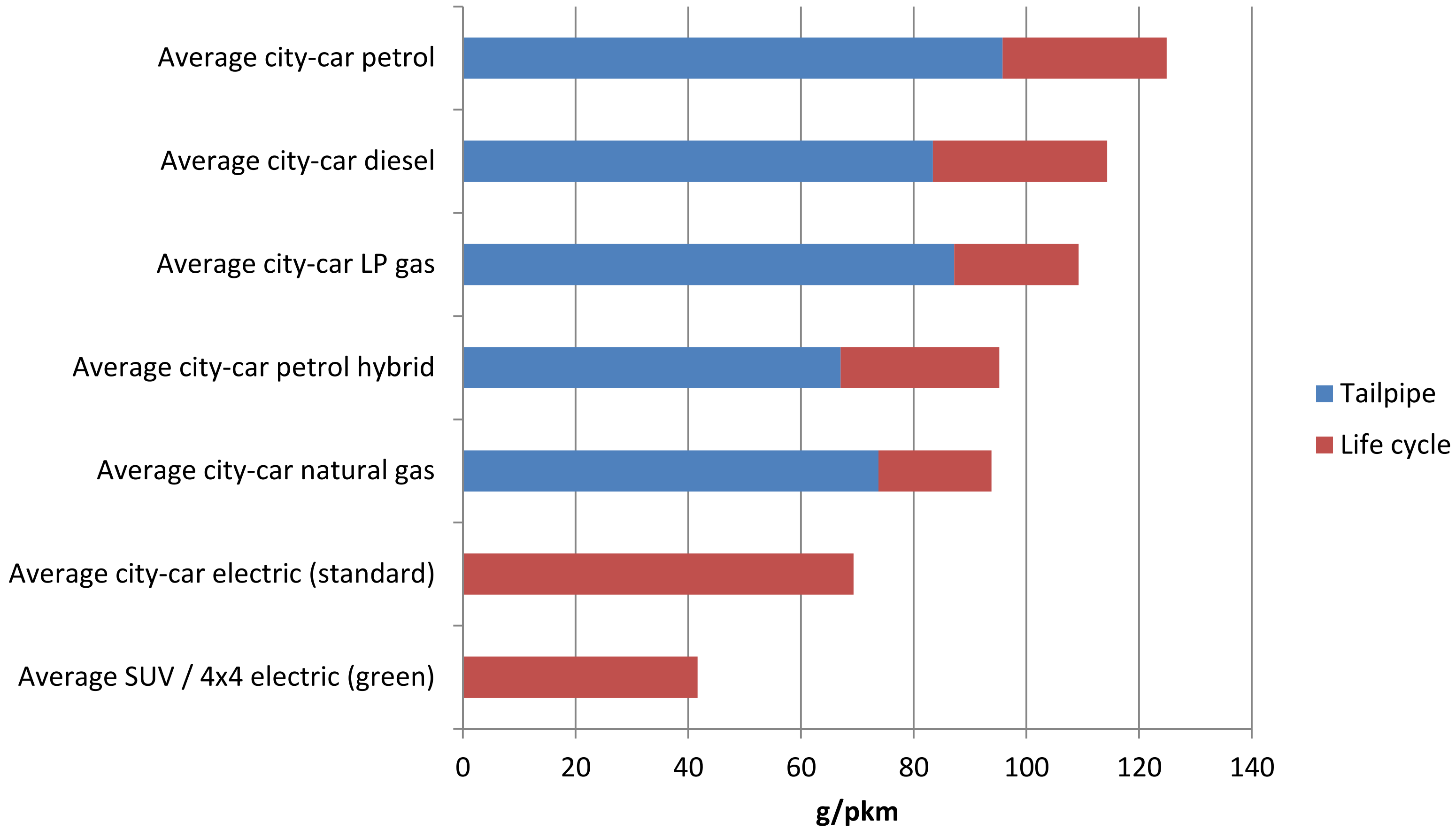
Energy Efficiency and the Demand for Energy Services

- Fuel use
- Fuel upstream
- Embodied

Chester http://www.transportationlca.org/tlcadb.html

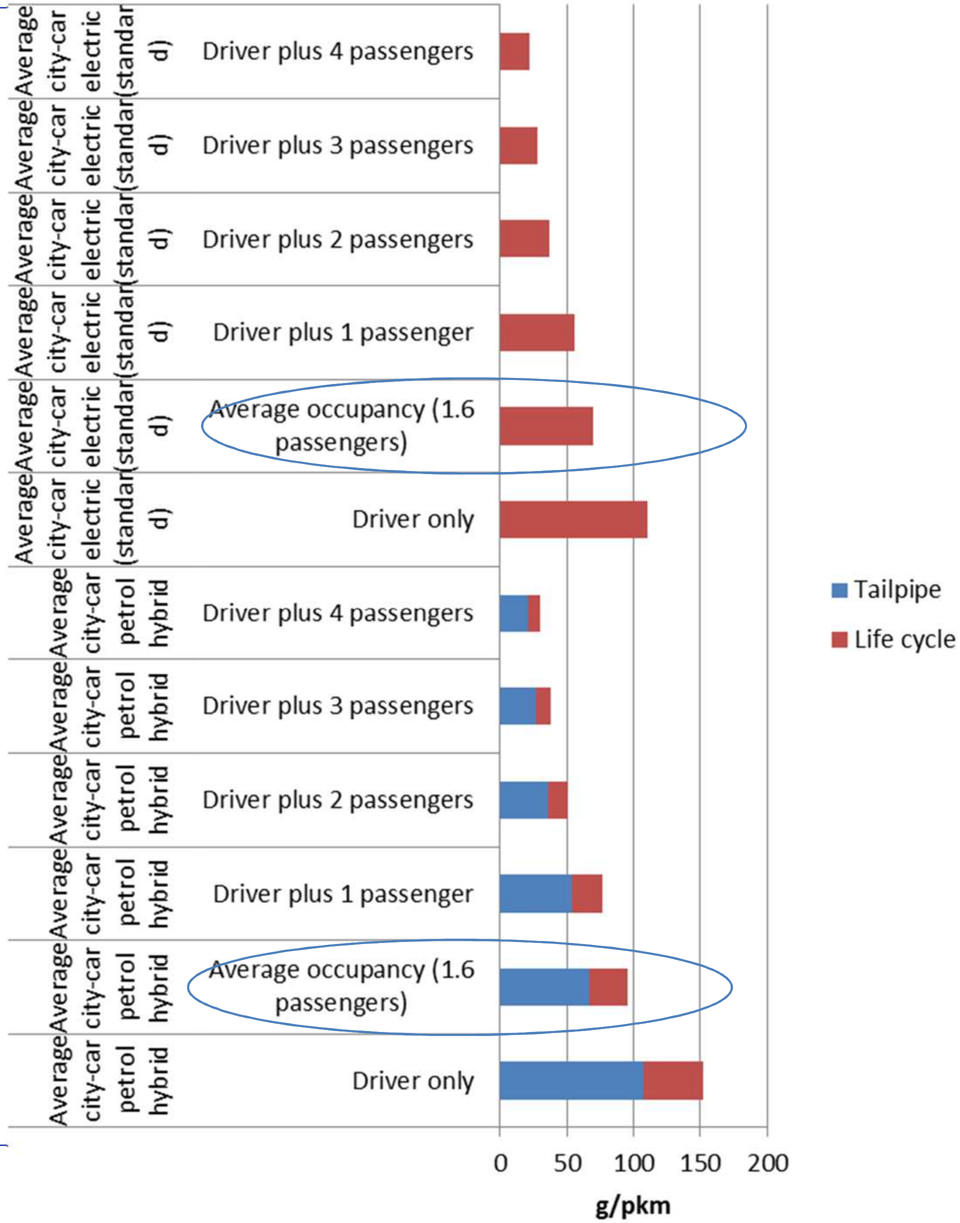


Life cycle



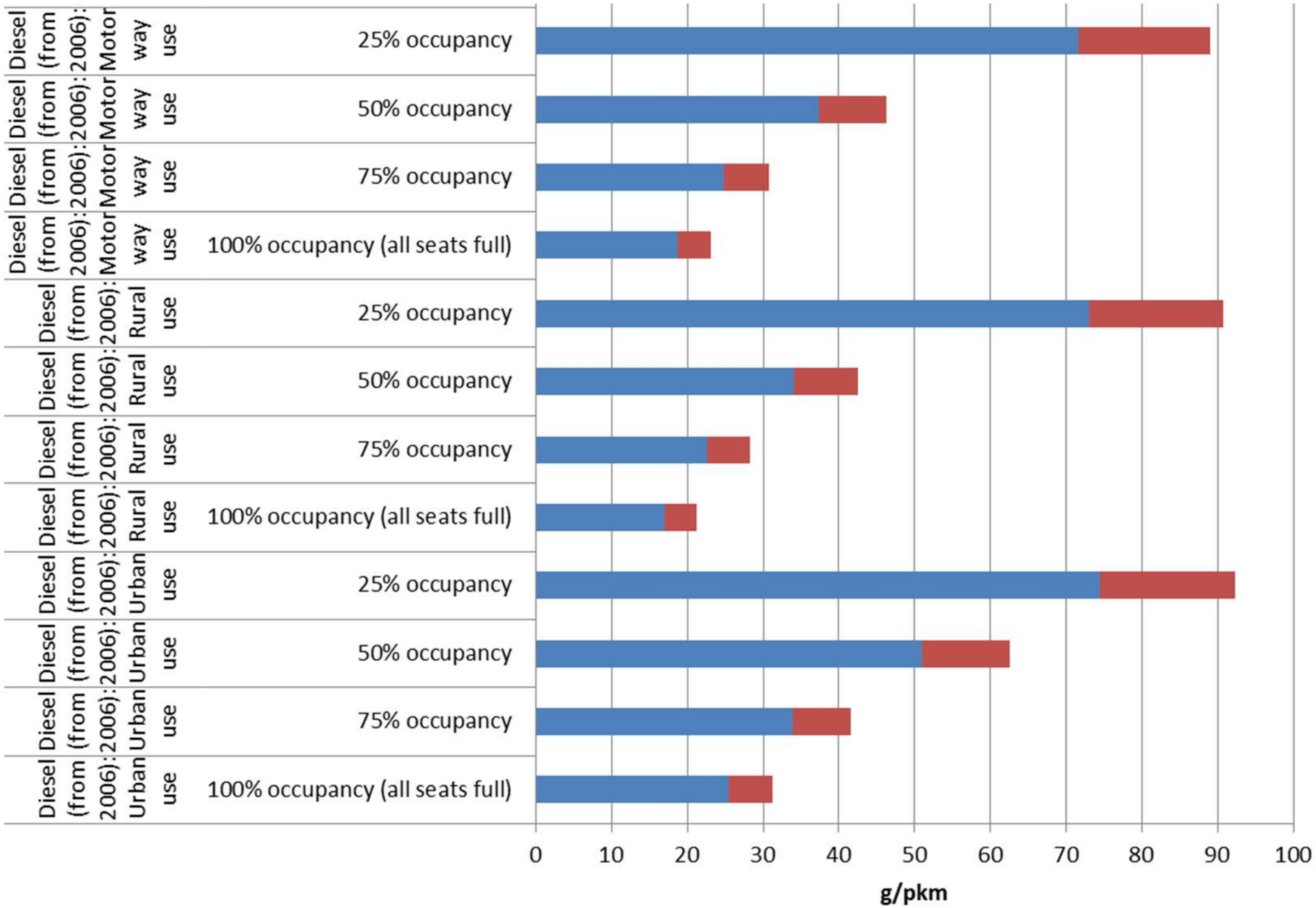
Average fleet CAR 1.6 passenger UK 2015

Life cycle



CAR

Life cycle



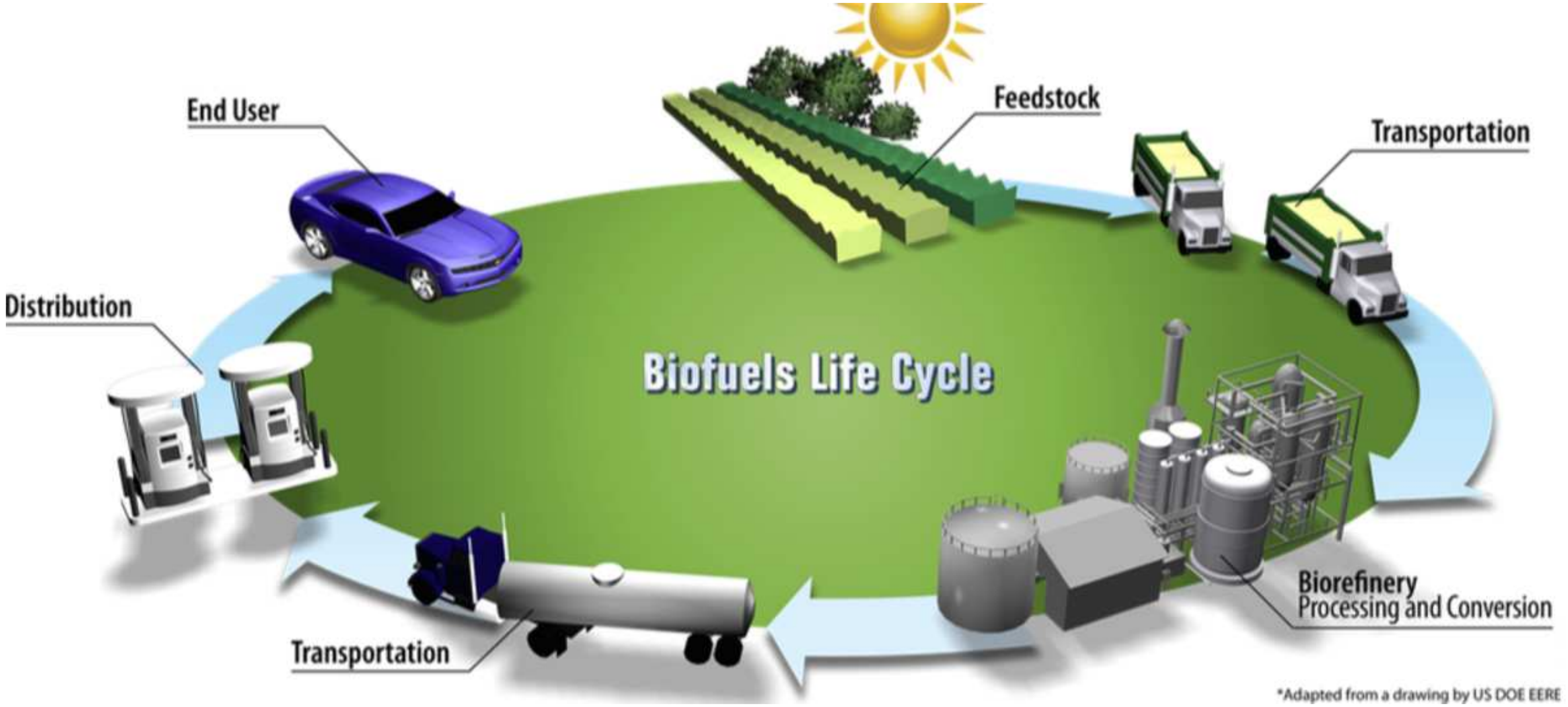
BUS

Life cycle

BIOFUELS

Life cycle

Well-to-Wheels



BIOFUELS

BIOFUELS feedstocks

Sunflower

Rapeseed (Colza)

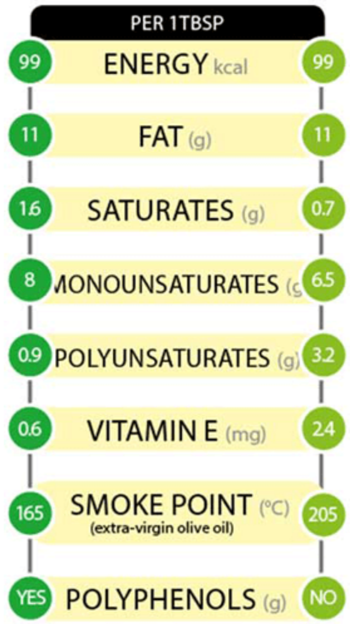
Palm

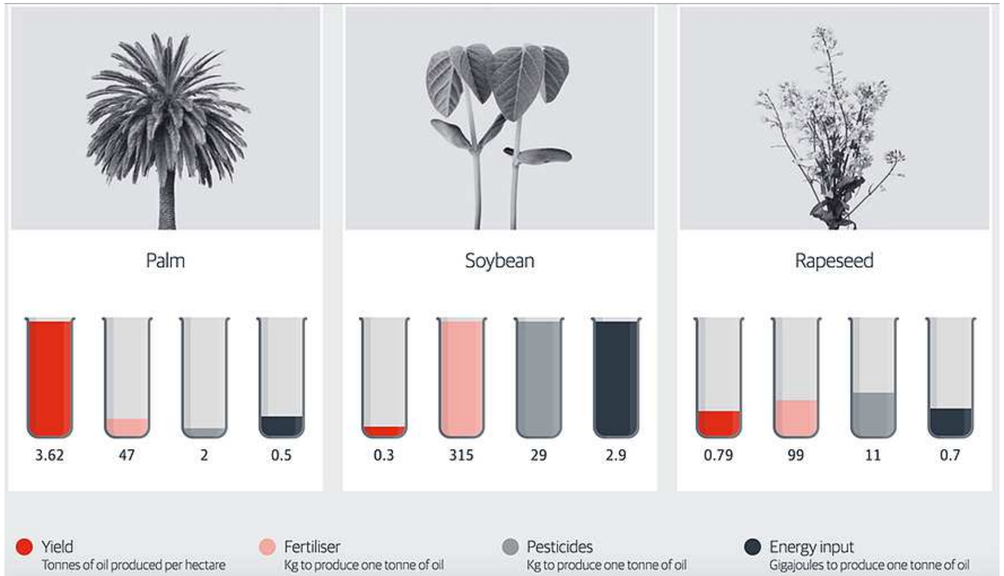
Soya

BIOFUELS feedstocks

1st food
Leftovers energy

Olive oil | Rapeseed oil





Life cycle Problem with palm oil

BIOFUELS feedstocks

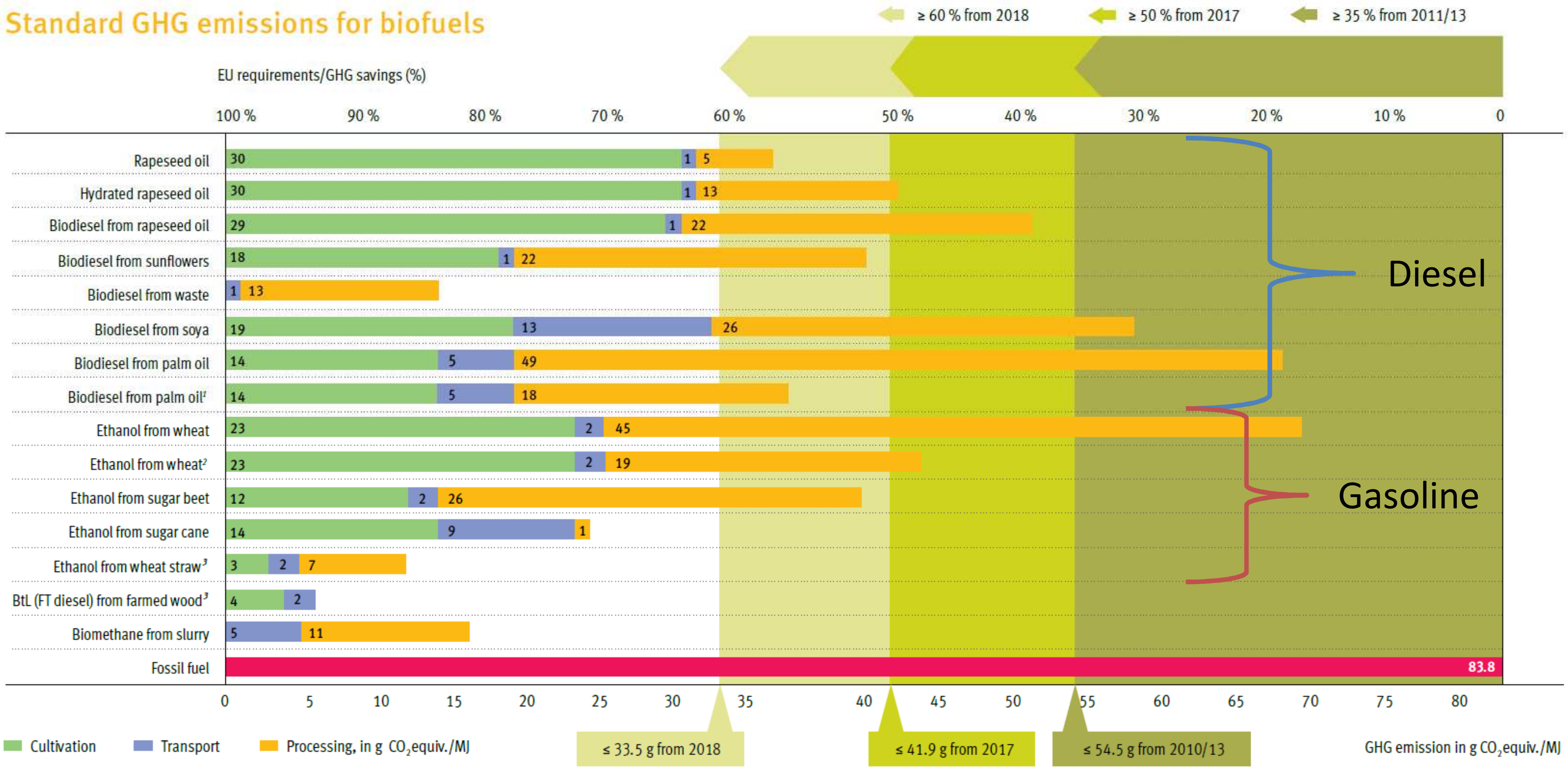
- **LAND-USE CHANGE**

Deforestation (ENDOGENOUS CULTIVATION OFF TO PLANT OTHER NON-ENDOGENOUS SPECIES)

- **SOCIAL DIMENSION OF SUSTAINABILITY**

e.g. Colombia move
poor people to other lands, NO MONEY COMPENSATION, and they are sometimes the workers to cultivate palm oil

Well-to-Wheels



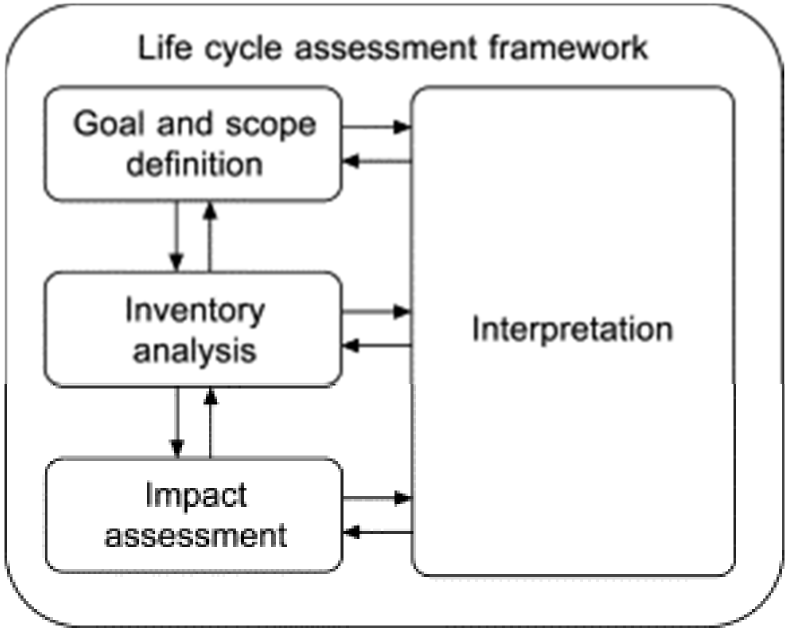
[1] With methane capture; [2] Natural gas CHP; [3] Future biofuel options – basis: estimated standard figures from 2009/28/EC

Source: FNR, according to UFOP (2011 – EU Directive 2009/28/EC)

LCA

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

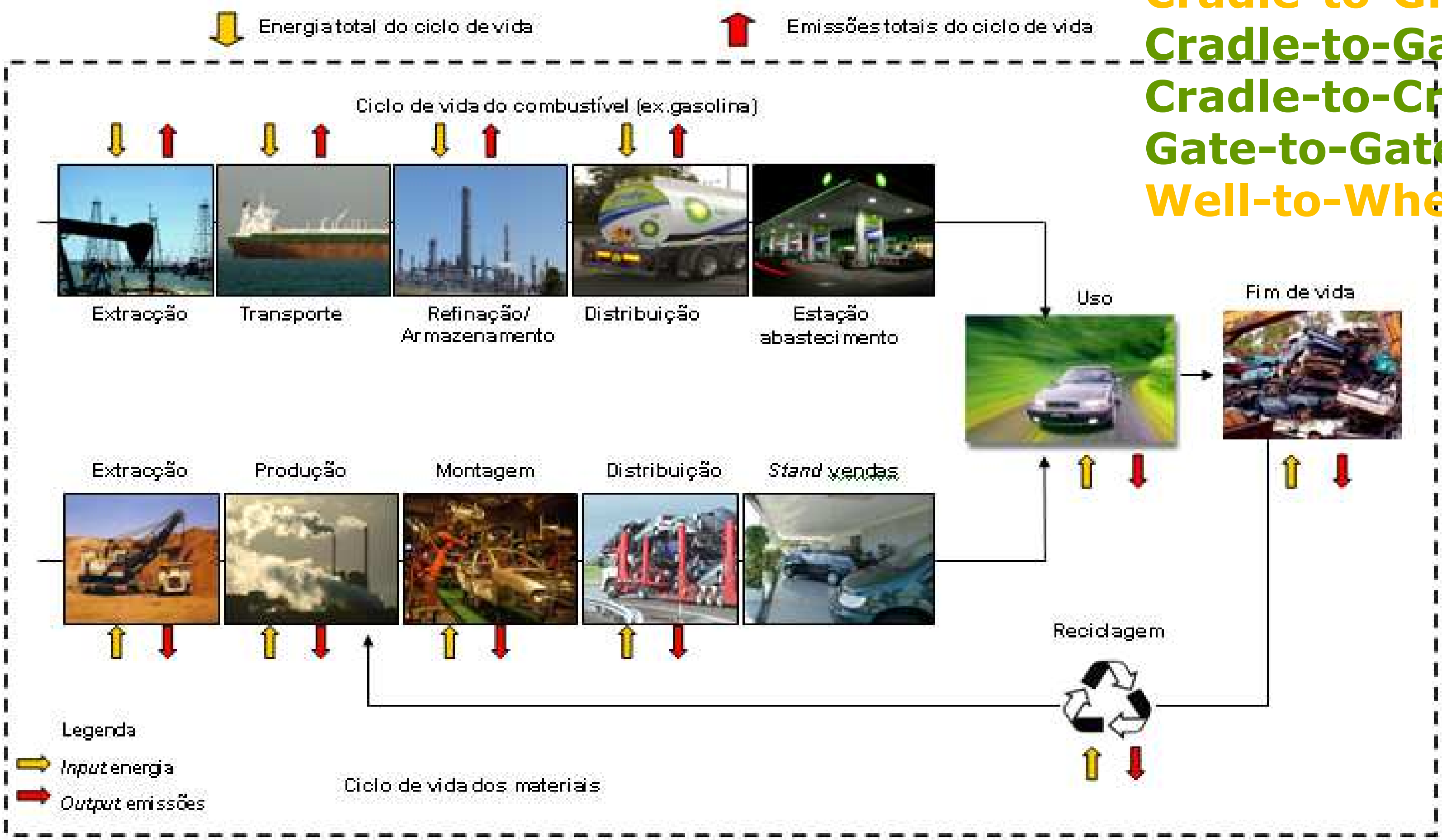
- Raw material extraction
- Materials processing
- Manufacture
- Distribution
- Use
- Maintenance
- Disposal or recycling



Steps as in ISO 14040:2006 and 14044:2006

Goal, scope and definition

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



Goal, scope and definition

Function of the system in analysis:

Transport passengers **p$_x$km**

Transport goods **ton$_x$km**

Printer **1000 prints**

Clothes **100 t-shirts**

Software

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

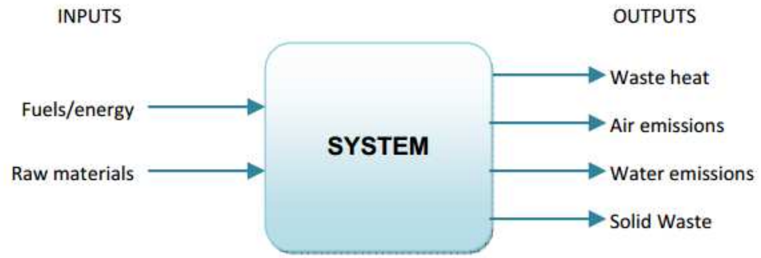
Boustead	www.boustead-consulting.co.uk
Eco-it	www.pre.nl
Ecopro	www.sinum.com
Ecoscan	www.ind.tno.nl
Euklid	www.ivv.fhg.de
KCL Eco	www.kcl.fi/eco
Gabi	www.gabi-software.com
LCAit	www.ekologik.cit.chalmers.se
Miet	www.leidenuniv.nl/cml/ssp/software
Pems	www.piranet.com/pack/lca_software.htm
SimaPro	www.pre.nl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

Generic

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

Inventory



For refinery producing diesel fuel…..e.g. identification of inflows and outflows…..and quantification

Refinery Configurations in PRELIM

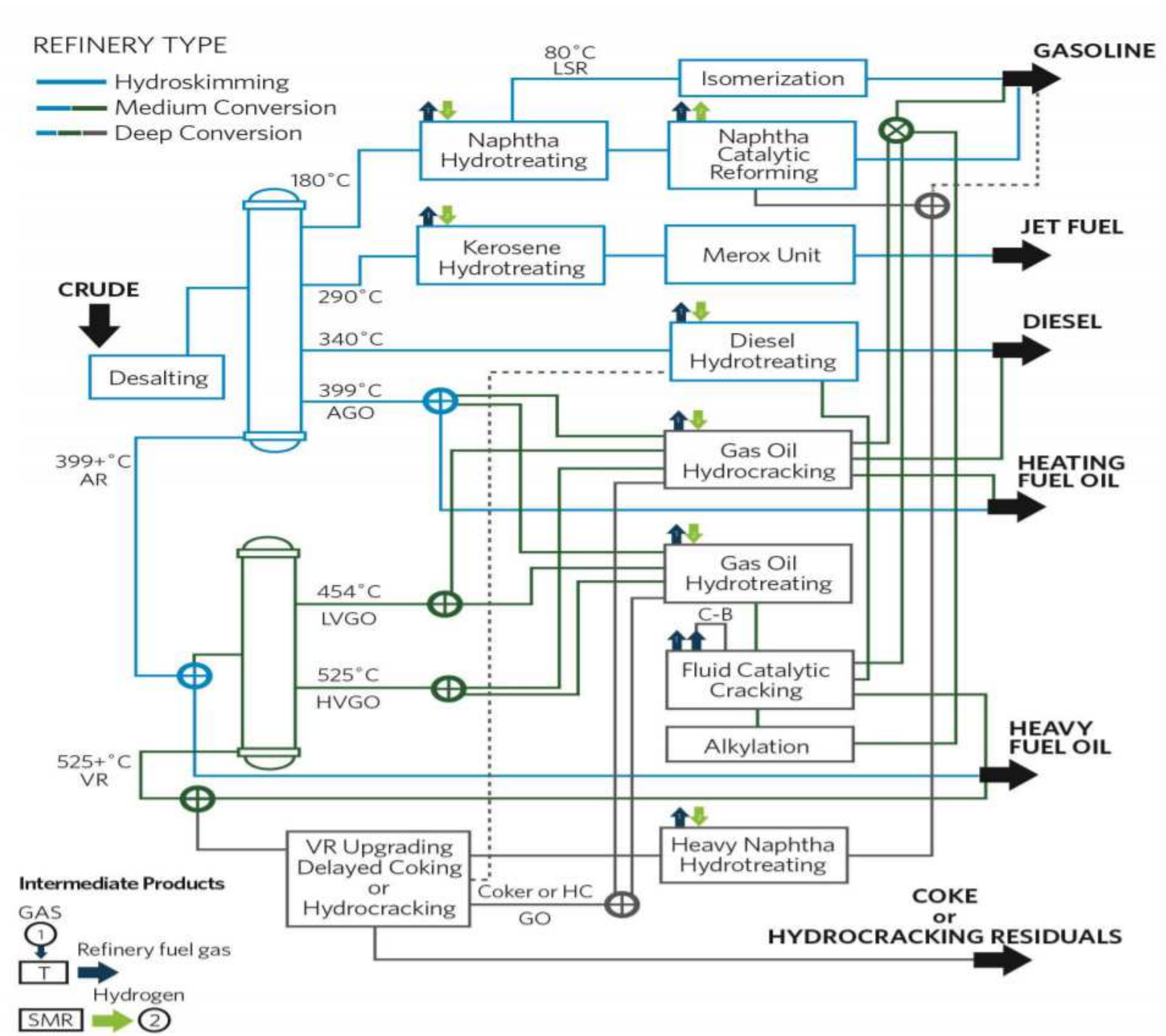


Table 5.58. Main inventory data for the coprocessing refinery.

(All the values are expressed per FU (kg / MJ_{Prod}); kJ / MJ_{Prod} for electricity)

INPUTS	*Case 1*	*Case 2*	*Case 3*	*Case 4*
From the technosphere				
Crude oil	$2.47\cdot10^{-2}$	$2.32\cdot10^{-2}$	$2.35\cdot10^{-2}$	$2.22\cdot10^{-2}$
HDO-oil	-	$1.92\cdot10^{-3}$	$1.36\cdot10^{-3}$	$3.12\cdot10^{-3}$
Char	-	$4.69\cdot10^{-4}$	$3.32\cdot10^{-4}$	$7.63\cdot10^{-4}$
Hydrogen	-	-	$3.32\cdot10^{-4}$	$2.44\cdot10^{-4}$
Natural gas	$1.75\cdot10^{-4}$	$1.65\cdot10^{-4}$	$2.74\cdot10^{-4}$	$5.76\cdot10^{-4}$
Water	$8.74\cdot10^{-4}$	$6.71\cdot10^{-4}$	$5.02\cdot10^{-3}$	$4.71\cdot10^{-3}$
MEA (aq)	$5.86\cdot10^{-6}$	$5.07\cdot10^{-3}$	$9.62\cdot10^{-6}$	$1.29\cdot10^{-5}$
Oxygen	$7.13\cdot10^{-4}$	$1.19\cdot10^{-3}$	$1.04\cdot10^{-3}$	$1.50\cdot10^{-3}$
Zeolite (Y)	$3.29\cdot10^{-6}$	$8.45\cdot10^{-6}$	$3.13\cdot10^{-6}$	$1.29\cdot10^{-5}$
NiMo/Al_2O_3	$1.52\cdot10^{-7}$	$1.43\cdot10^{-7}$	$2.51\cdot10^{-7}$	$2.37\cdot10^{-7}$
Dolomite	$7.09\cdot10^{-10}$	$1.02\cdot10^{-9}$	$9.23\cdot10^{-10}$	$1.21\cdot10^{-9}$
Olivine	$2.34\cdot10^{-7}$	$2.72\cdot10^{-7}$	$2.48\cdot10^{-7}$	$3.21\cdot10^{-7}$
Fe-Cr (HTS)	$2.49\cdot10^{-9}$	$2.79\cdot10^{-9}$	$2.71\cdot10^{-9}$	$2.92\cdot10^{-9}$
Cu-Zn (LTS)	$1.23\cdot10^{-9}$	$1.38\cdot10^{-9}$	$1.34\cdot10^{-9}$	$1.45\cdot10^{-9}$
Co-Mo/Al_2O_3	$3.23\cdot10^{-7}$	$3.25\cdot10^{-7}$	$3.30\cdot10^{-7}$	$3.29\cdot10^{-7}$
Electricity (kJ / MJ_{Prod})	6.25	6.22	6.53	6.78
From nature				
Air	$3.24\cdot10^{-2}$	$3.44\cdot10^{-2}$	$3.19\cdot10^{-2}$	$3.27\cdot10^{-2}$
OUTPUTS				
Products				
Propane	$1.71\cdot10^{-4}$	$1.99\cdot10^{-4}$	$2.14\cdot10^{-4}$	$2.47\cdot10^{-4}$
Butane	$3.32\cdot10^{-4}$	$2.95\cdot10^{-4}$	$3.39\cdot10^{-4}$	$3.75\cdot10^{-4}$
Gasoline	$4.89\cdot10^{-3}$	$4.94\cdot10^{-3}$	$6.63\cdot10^{-3}$	$6.23\cdot10^{-3}$
Kerosene	$6.83\cdot10^{-3}$	$1.01\cdot10^{-2}$	$4.78\cdot10^{-3}$	$8.89\cdot10^{-3}$
Diesel	$1.07\cdot10^{-2}$	$7.32\cdot10^{-3}$	$1.11\cdot10^{-2}$	$7.26\cdot10^{-3}$
Hydrogen	$4.89\cdot10^{-5}$	$6.77\cdot10^{-5}$	-	-
Wastes to treatment				
Waste water	$2.53\cdot10^{-3}$	$2.97\cdot10^{-3}$	$3.13\cdot10^{-3}$	$2.89\cdot10^{-3}$
Sulphur	$3.51\cdot10^{-5}$	$3.33\cdot10^{-5}$	$2.85\cdot10^{-5}$	$2.87\cdot10^{-5}$
Emissions to the air				
CO_2	$8.72\cdot10^{-3}$	$1.02\cdot10^{-2}$	$8.80\cdot10^{-3}$	$9.97\cdot10^{-3}$
H_2O	$3.33\cdot10^{-3}$	$3.16\cdot10^{-3}$	$3.55\cdot10^{-3}$	$3.42\cdot10^{-3}$
C1	-	$2.93\cdot10^{-16}$	$1.27\cdot10^{-22}$	$8.09\cdot10^{-33}$
CO	$2.63\cdot10^{-5}$	$2.49\cdot10^{-5}$	$2.17\cdot10^{-5}$	$2.05\cdot10^{-5}$
O_2	$1.00\cdot10^{-3}$	$1.03\cdot10^{-3}$	$9.55\cdot10^{-4}$	$9.88\cdot10^{-4}$
N_2	$2.52\cdot10^{-2}$	$2.67\cdot10^{-2}$	$2.48\cdot10^{-2}$	$2.54\cdot10^{-2}$
N_2O	$3.70\cdot10^{-9}$	$5.19\cdot10^{-9}$	$5.26\cdot10^{-9}$	$4.93\cdot10^{-9}$
NO_2	$4.29\cdot10^{-8}$	$5.48\cdot10^{-8}$	$5.46\cdot10^{-8}$	$5.21\cdot10^{-8}$
NO	$4.63\cdot10^{-5}$	$4.89\cdot10^{-5}$	$4.96\cdot10^{-5}$	$4.66\cdot10^{-5}$
S	$2.97\cdot10^{-28}$	$1.53\cdot10^{-19}$	$1.49\cdot10^{-22}$	$8.41\cdot10^{-26}$
H_2S	$8.45\cdot10^{-31}$	$3.50\cdot10^{-15}$	$4.55\cdot10^{-20}$	$9.04\cdot10^{-26}$
NH_3	$9.46\cdot10^{-19}$	$7.80\cdot10^{-11}$	$3.46\cdot10^{-13}$	$4.83\cdot10^{-17}$
SO_2	$2.91\cdot10^{-5}$	$3.38\cdot10^{-5}$	$2.80\cdot10^{-5}$	$3.26\cdot10^{-5}$

Inventory

JEC WTW study Version 4a

WTT pathway Back to menu

Code		**COD1**	*Description*
Final fuel		**Diesel fuel**	Crude oil from typical EU supply, transport by sea, refining in EU (marginal production), typical EU distribution and retail.

Results

		Energy expended MJ/MJ$_{diesel}$	GHG emissions g CO_{2eq}/MJ$_{diesel}$ Total	as CO_2	as CH_4	as N_2O
Standard steps	*Actual steps*					
Production & conditioning at source	Crude oil production	0.07	4.7	4.00	0.67	0.00
Transformation at source	*NA*					
Transportation to market	Crude oil transport	0.01	1.0	0.97	0.00	0.00
Transformation near market	Crude refining, marginal diesel	0.10	8.6	8.60	0.00	0.00
Conditioning & distribution	Distribution	0.01	0.6	0.58	0.02	0.01
	Dispensing at retail site	0.01	0.5	0.48	0.03	0.00
Total WTT		**0.20**	**15.4**			
Min		*0.18*	*13.8*			
Max		*0.23*	*17.0*			
of which Fossil		0.20				
of which Nuclear		0.01				
Combustion CO_2 emissions			73.2			
of which Renewable(*)			0.0			
Total non-renewable emissions including combustion			**88.6**			

(*) Shown as negative

Energy

Mass

Economic value

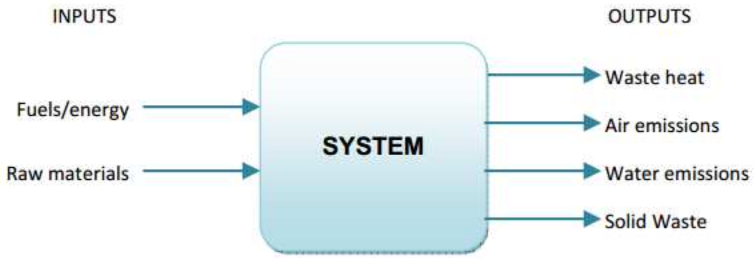
System expansion

Input data

Physical properties of products and intermediates relevant to this pathway

		Crude oil	Diesel
Density	kg/m^3	820	832
LHV	MJ/kg	42.0	43.1
Carbon content	% m	86.5%	86.1%
CO_2 emission factor	g CO_2/MJ	75.5	73.2
(assuming total combustion)	kg CO_2/kg	3.17	3.16

Inventory



For car materials…..e.g.

GREET

1) Summary of Energy Consumption and Emissions: GJ or grams per-vehicle lifetime
1.1) ICEV: Conventional Material

300 000 km

	GJ or grams per vehicle lifetime					Percentage of each stage			
	Components	ADR	Batteries	Fluids	Total	Components	ADR	Batteries	Fluids
Total energy	69.278	11.015	3.691	12.211	96.196	72.0%	11.5%	3.8%	12.7%
Fossil fuels	62.345	8.367	2.590	12.064	85.366	73.0%	9.8%	3.0%	14.1%
Coal	17.908	2.669	1.302	0.308	22.188	80.7%	12.0%	5.9%	1.4%
Natural gas	32.907	5.118	1.005	2.163	41.192	79.9%	12.4%	2.4%	5.3%
Petroleum	11.530	0.580	0.283	9.593	21.987	52.4%	2.6%	1.3%	43.6%
CO2	4,507,794	752,357	195,092	701,563	6,156,806	73.2%	12.2%	3.2%	11.4%
CH4	8803.870	1210.898	367.990	1143.375	11526.133	76.4%	10.5%	3.2%	9.9%
N2O	59.009	12.609	4.118	5.466	81.201	72.7%	15.5%	5.1%	6.7%
GHGs	4,727,750	783,940	204,774	729,479	6,445,943	73.3%	12.2%	3.2%	11.3%

gCO2eq per 1 diesel car 4.8 ton (32 g/km) 150 000 km

gCO2eq per 1 eletric car 7.2 ton (47.8 g/km) 150 000 km

Impact assessment

Calculate impact category, per FU:

- Global warming gCO_2 eq;
- Ozone depletion gCFC11 eq;
- Acidification gSO2 eq;
- Carcinogenic gPAH eq;
- Eutrophication gPO4 eq;
- Heavy metal g Pbeq;
- Summer smog gC2H4 eq;
- Winter smog gdust eq;
- Resource depletion %.

Carbon footprint or Global Warming potential

CO_2 equivalent or GHG

Intergovernmental Panel on Climate Change (IPCC)

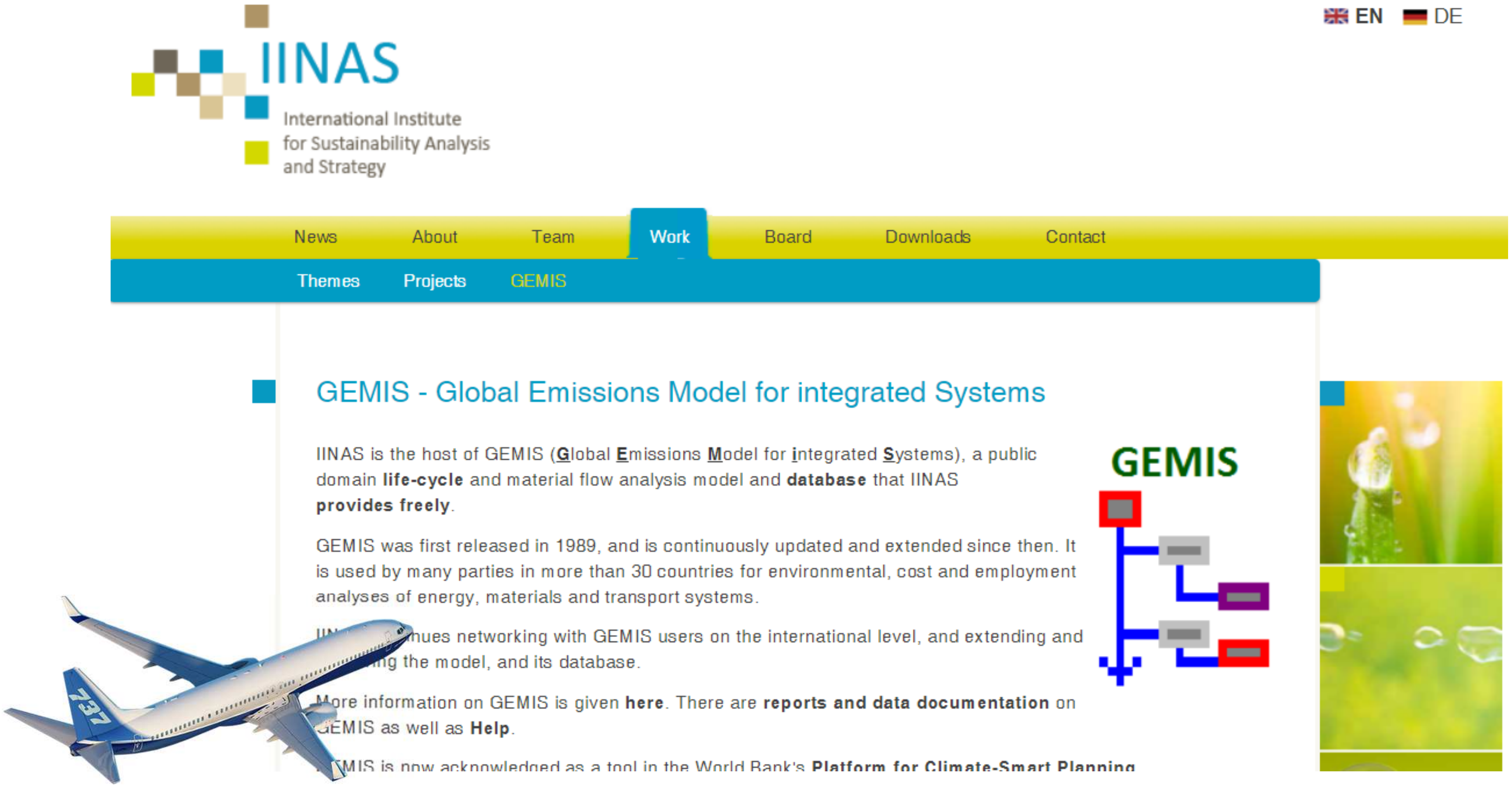
Industrial Designation or Common Name (years)	Chemical Formula	Lifetime (years)	RadiativeEfficiency (W m^{-2} ppb^{-1})	Global Warming Potential for Given Time Horizon: SAR‡ (100-yr)	20-yr	100-yr	500-yr
Carbon dioxide	CO_2	See below[a]	[b]$1.4x10^{-5}$	1	1	1	1
Methane[c]	CH_4	12[c]	$3.7x10^{-4}$	21	72	25	7.6
Nitrous oxide	N_2O	114	$3.03x10^{-3}$	310	289	298	153
Substances controlled by the Montreal Protocol							
CFC-11	CCl_3F	45	0.25	3,800	6,730	4,750	1,620
CFC-12	CCl_2F_2	100	0.32	8,100	11,000	10,900	5,200
CFC-13	$CClF_3$	640	0.25		10,800	14,400	16,400
CFC-113	CCl_2FCClF_2	85	0.3	4,800	6,540	6,130	2,700
CFC-114	$CClF_2CClF_2$	300	0.31		8,040	10,000	8,730
CFC-115	$CClF_2CF_3$	1,700	0.18		5,310	7,370	9,990
Halon-1301	$CBrF_3$	65	0.32	5,400	8,480	7,140	2,760
Halon-1211	$CBrClF_2$	16	0.3		4,750	1,890	575
Halon-2402	$CBrF_2CBrF_2$	20	0.33		3,680	1,640	503
Carbon tetrachloride	CCl_4	26	0.13	1,400	2,700	1,400	435

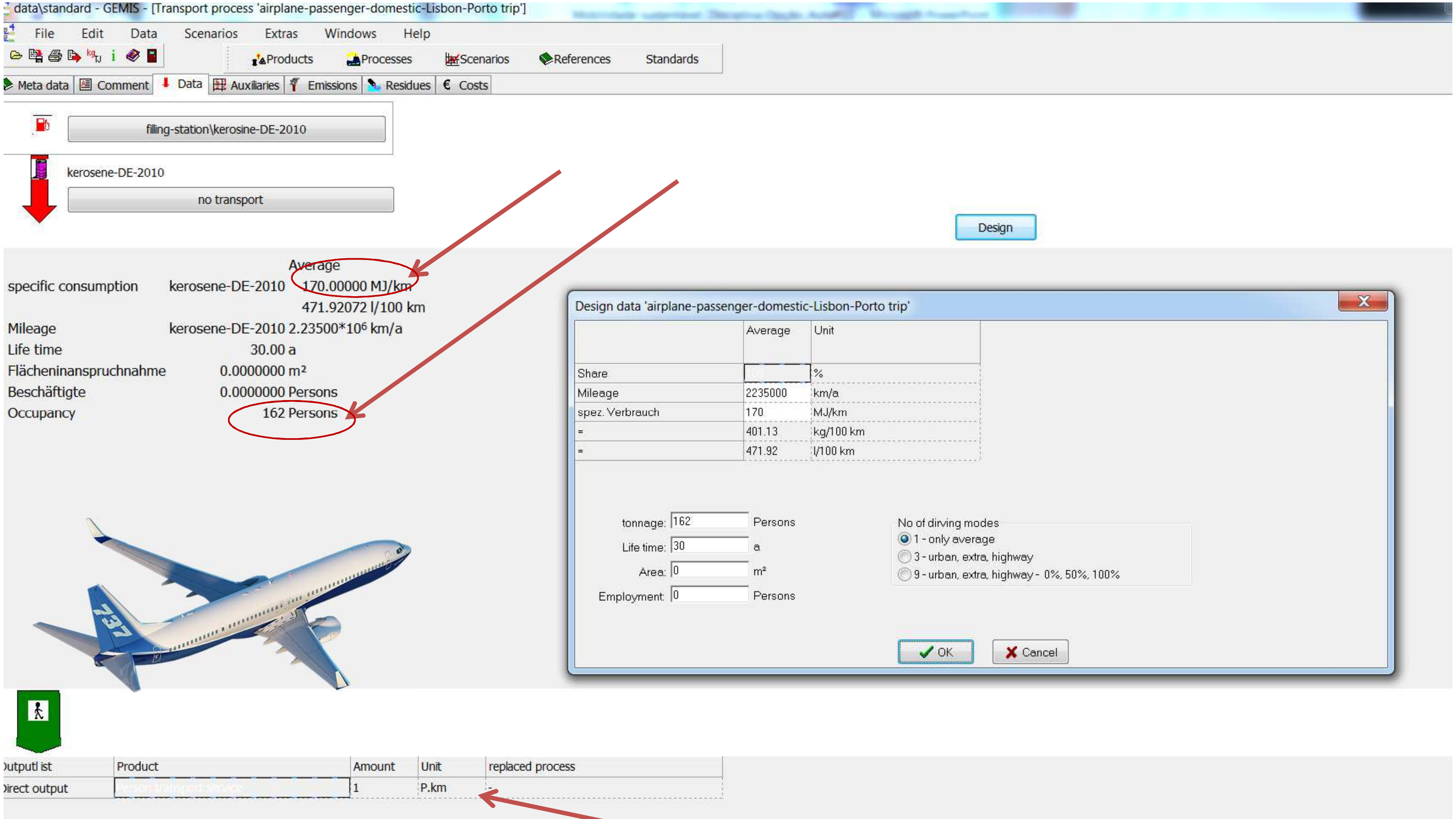
CO_2 equivalent or GHG

Intergovernmental Panel on Climate Change (IPCC)

Industrial designation or common name	Chemical formula	GWP values for 100-year time horizon		
		Second Assessment Report (SAR)	Fourth Assessment Report (AR4)	Fifth Assessment Report (AR5)
Carbon dioxide	CO_2	1	1	1
Methane	CH_4	21	25	28
Nitrous oxide	N_2O	310	298	265

GEMIS-Free inventory

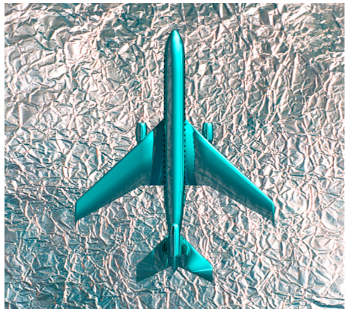



data\standard - GEMIS - [Transport process 'airplane-passenger-domestic-Lisbon-Porto trip']
File Edit Data Scenarios Extras Windows Help
Products Processes Scenarios References Standards
Meta data Comment Data Auxiliaries Emissions Residues Costs
filling-station\kerosine-DE-2010
kerosene-DE-2010
no transport
Design
Average
specific consumption kerosene-DE-2010 170.00000 MJ/km
471.92072 l/100 km
Mileage kerosene-DE-2010 2.23500*10⁶ km/a
Life time 30.00 a
Flächeninanspruchnahme 0.0000000 m²
Beschäftigte 0.0000000 Persons
Occupancy 162 Persons
Design data 'airplane-passenger-domestic-Lisbon-Porto trip'
Average Unit
Share %
Mileage 2235000 km/a
spez. Verbrauch 170 MJ/km
= 401.13 kg/100 km
= 471.92 l/100 km
tonnage: 162 Persons
Life time: 30 a
Area: 0 m²
Employment: 0 Persons
No of dirving modes
1 - only average
3 - urban, extra, highway
9 - urban, extra, highway - 0%, 50%, 100%
OK
Cancel
737
Outputl ist Product Amount Unit replaced process
Direct output 1 P.km

GEMIS

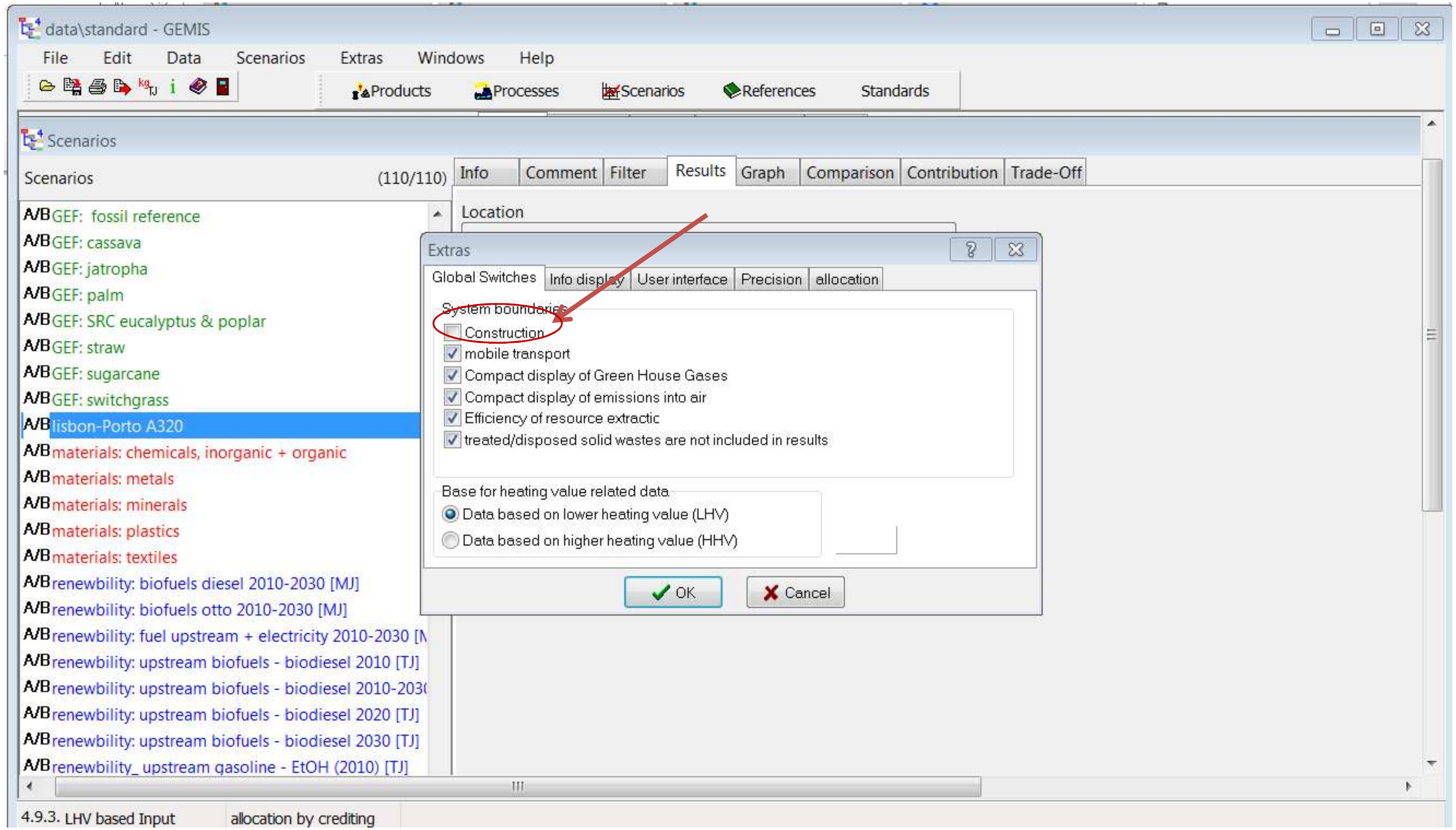
process delivering materials for construction	construction material	Amount [kg/Vehicle]	Transport system	Transport distance [
metal\Aluminium-mix-DE-2010	aluminium	5.3802E+4		0
chem-org\HDPE-DE-2010	HDPE-granulate	5.978E+3		0
Sum		5.978E+4		

54 ton of Aluminium



6 ton High Density Polyethylene

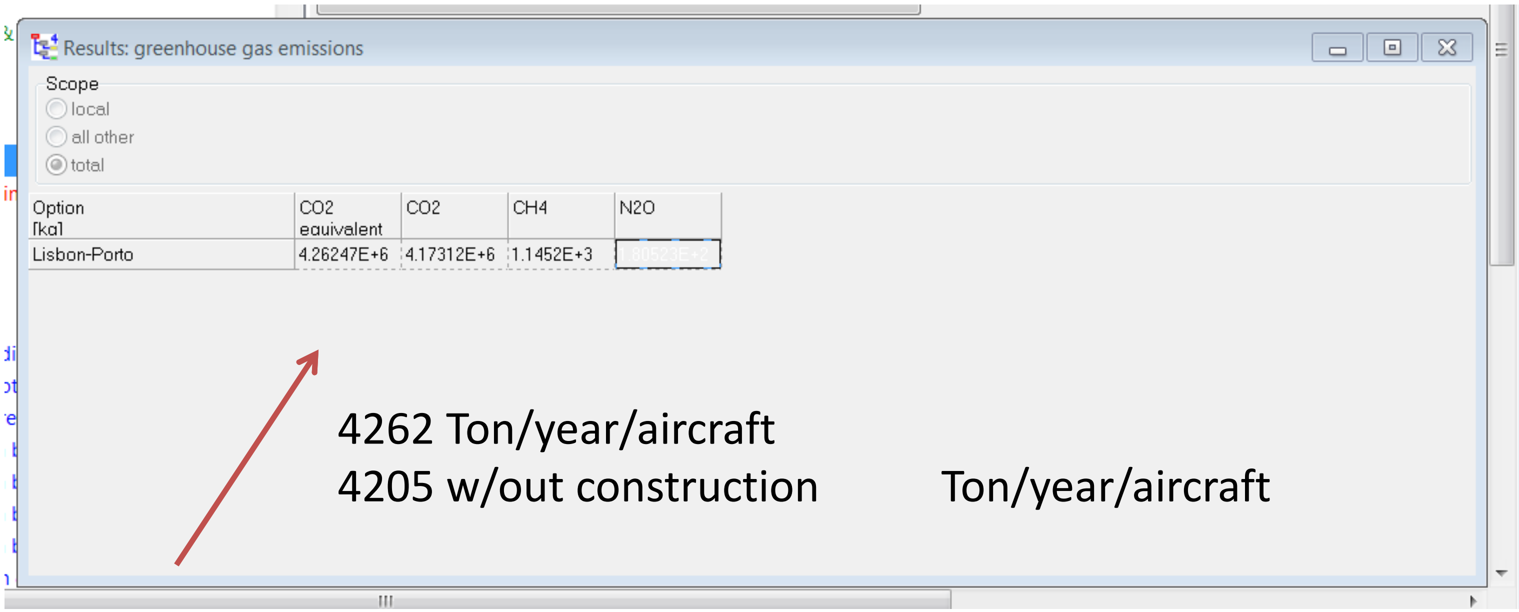
GEMIS


data\standard - GEMIS
File Edit Data Scenarios Extras Windows Help
Products Processes Scenarios References Standards
Scenarios
Scenarios (110/110)
Info Comment Filter Results Graph Comparison Contribution Trade-Off
Location
A/B GEF: fossil reference
A/B GEF: cassava
A/B GEF: jatropha
A/B GEF: palm
A/B GEF: SRC eucalyptus & poplar
A/B GEF: straw
A/B GEF: sugarcane
A/B GEF: switchgrass
A/B lisbon-Porto A320
A/B materials: chemicals, inorganic + organic
A/B materials: metals
A/B materials: minerals
A/B materials: plastics
A/B materials: textiles
A/B renewbility: biofuels diesel 2010-2030 [MJ]
A/B renewbility: biofuels otto 2010-2030 [MJ]
A/B renewbility: upstream biofuels - biodiesel 2010 [TJ]
A/B renewbility: upstream biofuels - biodiesel 2020 [TJ]
A/B renewbility: upstream biofuels - biodiesel 2030 [TJ]
A/B renewbility_ upstream gasoline - EtOH (2010) [TJ]
Extras
Global Switches Info display User interface Precision allocation
System boundaries
Construction
mobile transport
Compact display of Green House Gases
Compact display of emissions into air
Efficiency of resource extractic
treated/disposed solid wastes are not included in results
Base for heating value related data
Data based on lower heating value (LHV)
Data based on higher heating value (HHV)
OK
Cancel
4.9.3. LHV based Input
allocation by crediting

GEMIS

Pkm/year/aircraft = 162 pas/trip*2 trip/day*365 day/year*352 km/trip = 41627520

30 year lifetime materials



4262 Ton/year/aircraft

4205 w/out construction Ton/year/aircraft

To keep…..

European Commission

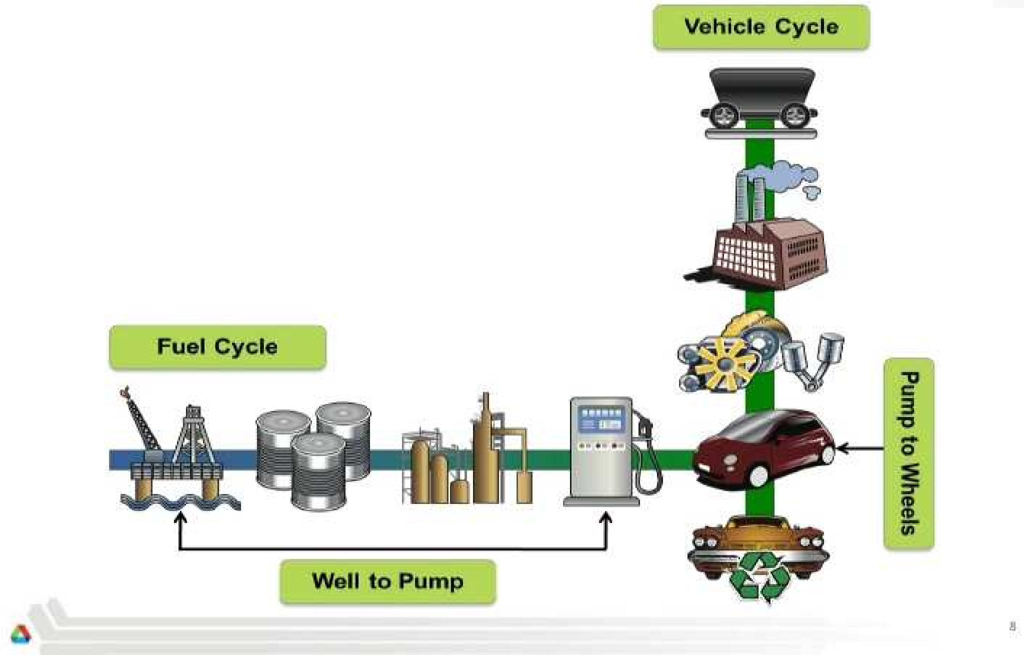
JRC TECHNICAL REPORTS

Fuel WTT — Diesel — 1.2 MJ/MJ
15.4 g/MJ

Argonne GREET LIFE-CYCLE MODEL

Production
Assembly
Dismantling
Recycling

ICE car — 75 GJ (0.5 MJ/km)
4.8 ton for 150000 km lifetime (32 g/km)



Why 100 years???

Intergovernmental Panel on Climate Change (IPCC)

- how well the gas absorbs energy (preventing it from immediately escaping to space)
- how long the gas stays in the atmosphere (CO_2 > 800 years; CH_4 <20 years; N_2O <130 years)

Uncertainty GWP ±35%

GWP ratio

$$GWP_i^{TH} = \frac{AGWP_i^{TH}}{AGWP_{CO_2}^{TH}} = \frac{\int_0^{TH} a_i \left[C_i(t)\right] dt}{\int_0^{TH} a_{CO_2} \left[C_{CO_2}(t)\right] dt}$$

Absolute global warming of CO_2 [$W.m^{-2}.kg^{-1}$]

TH is the chosen time horizon,

a is the instantaneous radiative forcing per unit mass increase in the atmosphere,

C(t) is the time-dependent atmospheric load of the released gas,

i is the released gas

The impulse response function for CO_2

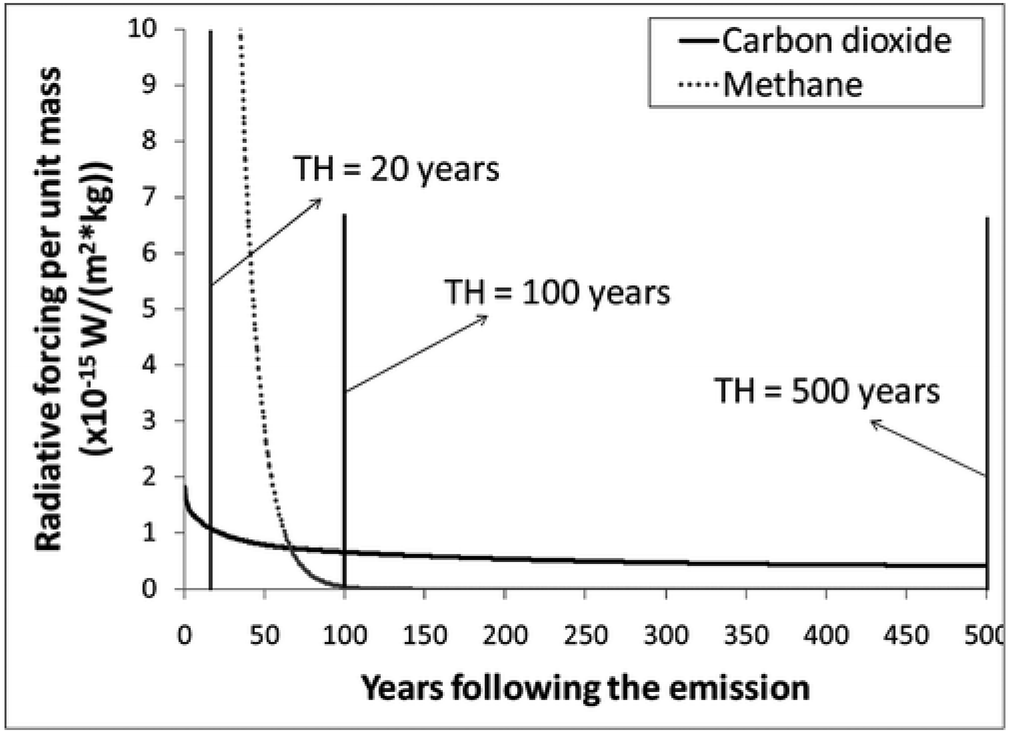
$$\mathrm{IRF}(t) = a_0 + \sum_{i=1}^{3} a_i \cdot \exp\left(\frac{-t}{\tau_i}\right)$$

389 ppm background

Where a0 = 0.217, a1 = 0.259, a2 = 0.338, a3 = 0.186, τ1 = 172.9 years, τ2 = 18.51 years, and τ3 = 1.186 years.

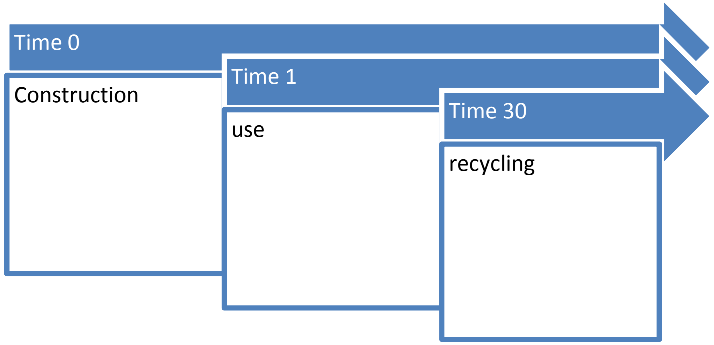
LCA

climate metrics in life-cycle assessment (LCA) aggregate the emission of greenhouse gases in one impact-triggering instant, rather than accommodating its distribution along a timeline



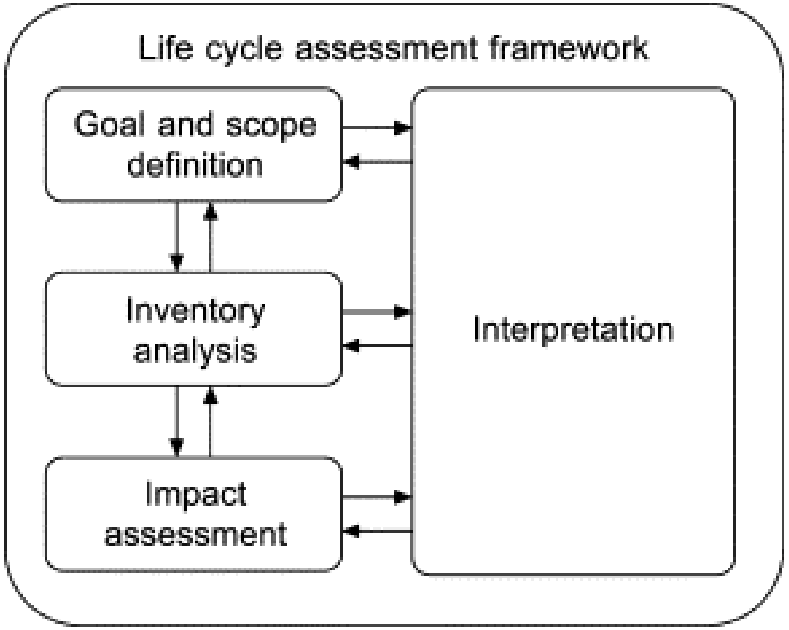
LCA static vs dynamic

Static vs Dynamic (time in years)



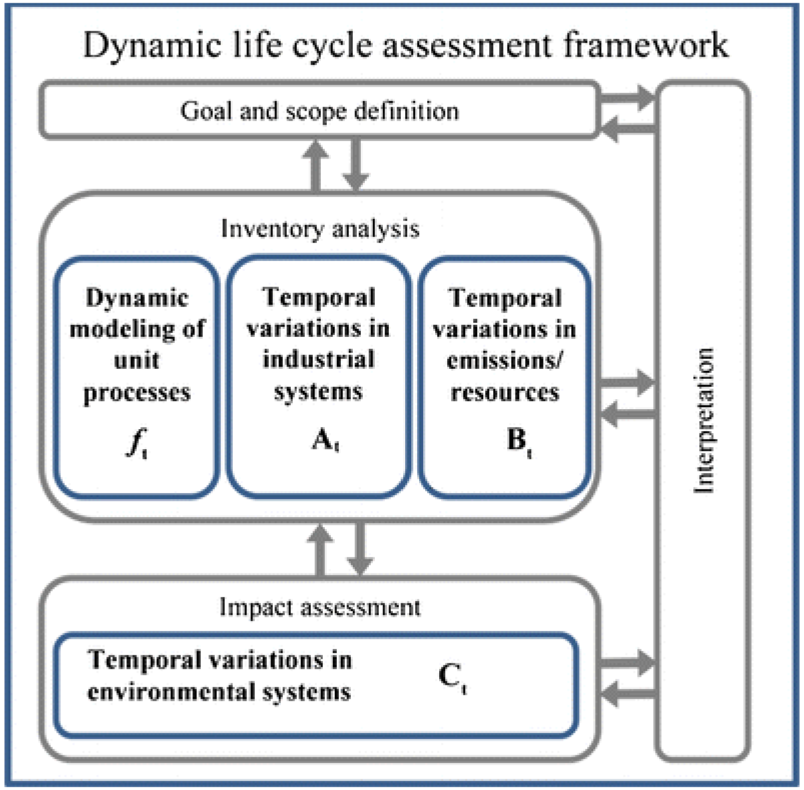
LCA static vs dynamic

static

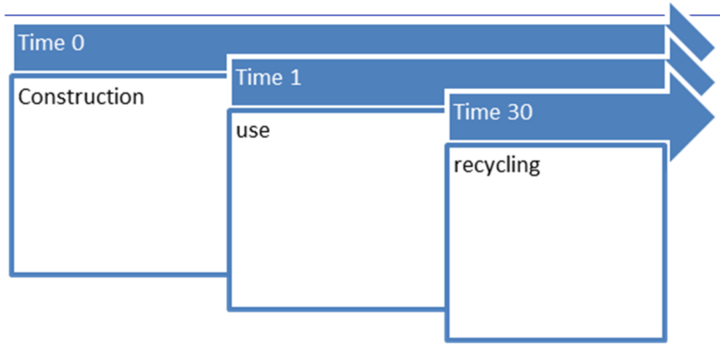


vs

dynamic



LCA static vs dynamic



Dynamic (time in years)

CO_2 pulses at different times $\Rightarrow$ different impacts

Dynamic LCI $\Rightarrow$ additional emission pulses

To keep…..LCA static

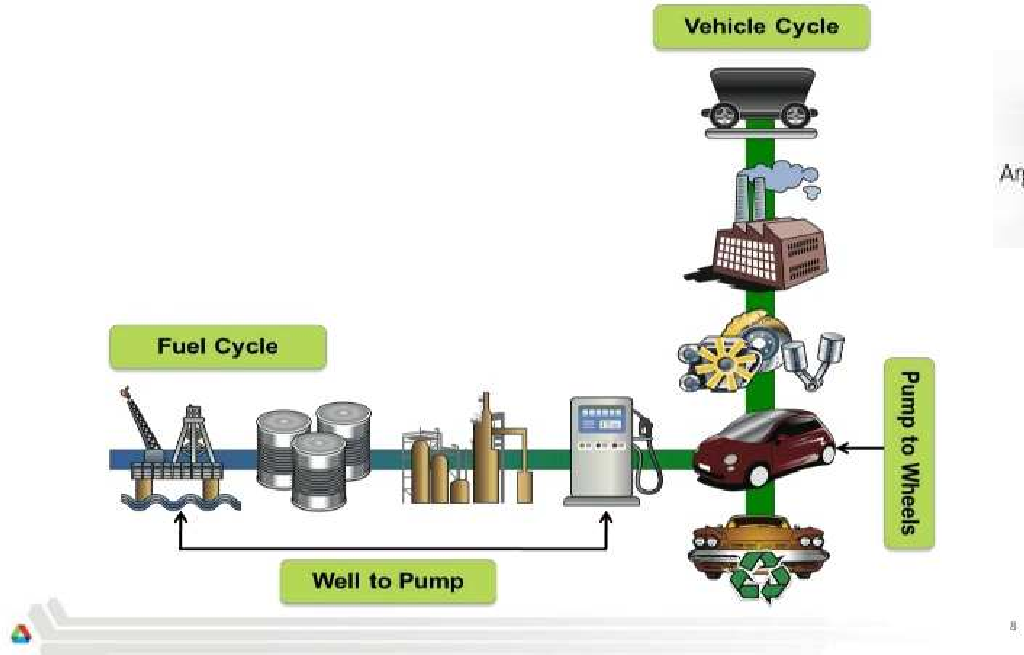
Fuel WTT — Diesel — 1.2 MJ/MJ
15.4 g/MJ

JRC TECHNICAL REPORTS

Production
Assembly
Dismantling
Recycling

ICE car — 75 GJ (0.5 MJ/km)
4.8 ton CO2eq for 150 000 km lifetime (32 g/km)

Static



LCA static

e.g. Steel vs aluminium

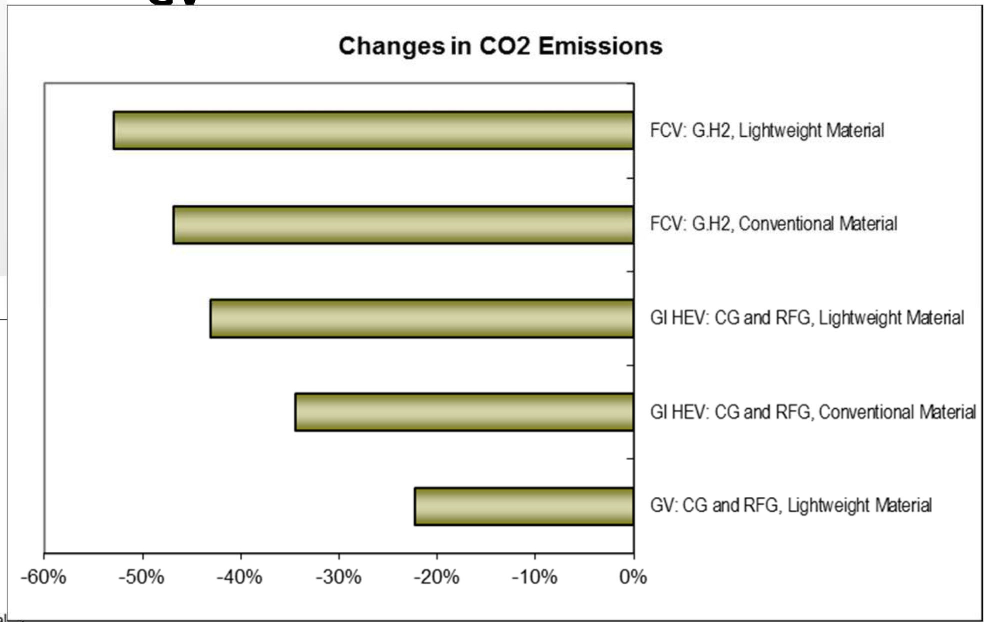
Fuel WTT **The same**

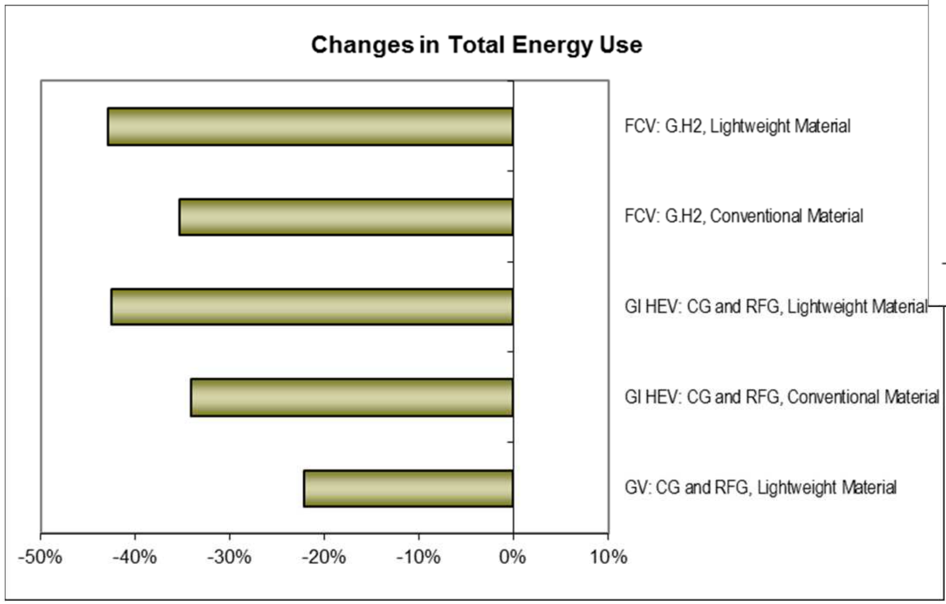
Fuel TTW **Lightweight** ⇒ less final energy consumption

Production
Assembly
Dismantling
Recycling **Different resource ⇒ different values**

LCA static

e.g. More aluminium vs conventional more steel; ref conventional gasoline GV





Cradle-to-Grave (includes materials and fuels)

You learned….

- General methodology Life cycle assessment - LCA;
- Functional unit (FU) for transport: pkm
- WTW: Well-to-Wheels for transport fuels; Materials cradle-to-grave;
- Static and dynamic differences;
- IPCC updated values.

Obrigado

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da Universidade
de Lisboa