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Life Cycle Assessment

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LIFE CYCLE ASSESSMENT OF ELECTROMOBILITY
ANSWERS AND CHALLENGES

April 6, 2011, 9h15, Zürich, ETH Central Building, Semper Aula

Comparative life-cycle assessment of electric and conventional vehicles in Portugal

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Outline

- Scope of the study
- Energy and environmental life-cycle results
- Vehicle life-cycle GHG emissions per GHG intensity of electricity: sensitivity analysis
- Concluding remarks

Vehicle Characteristics and Assumptions

			Urban *("city car")* | Suburban *(based on "Golf" car)*									
	Vehicle type		**BEV**		**PHEV40**		**PHEV20**		**Gas**oline **(ICE)**		**Diesel (ICE)**	
	Weight of vehicle (battery incl.) [kg]		883	1202	962	1284	927	1231	800	1058	800	1058
Energy consumption	Gasoline | Diesel [l/km]		-	-	0.04	0.052	0.04	0.052	0,04	0,052	0.036	0.045
	Normal Charge (η=80%)	Electricity [kWh/km]	0.125	0.1875	0.125	0.1875	0.125	0.1875	-	-	-	-
	Average mix consumption [l/km & kWh/km]		-	-	0.02 & 0.063	0.026 & 0.094	0.028 & 0.038	0.036 & 0.056	-	-	-	-
Li-Ion Battery pack (Oxide Manganese)	Weight [kg]		220	329	71	106	36	53	-	-	-	-
	capacity [kWh]		25	37.5	8	12	4	6	-	-	-	-
	Driving Range (EV) [km] Full charge/discharge up to 30%		140	140	44.8	44.8	22.4	22.4	-	-	-	-
	Maximum Driving Range (EV) [km] Full charge/ full discharge		200	200	64	64	32	32	-	-	-	-
	Number of batteries in 200 000 km, 10 years		2	2	3	3	3	3	-	-	-	-

Portugal Electricity Mix

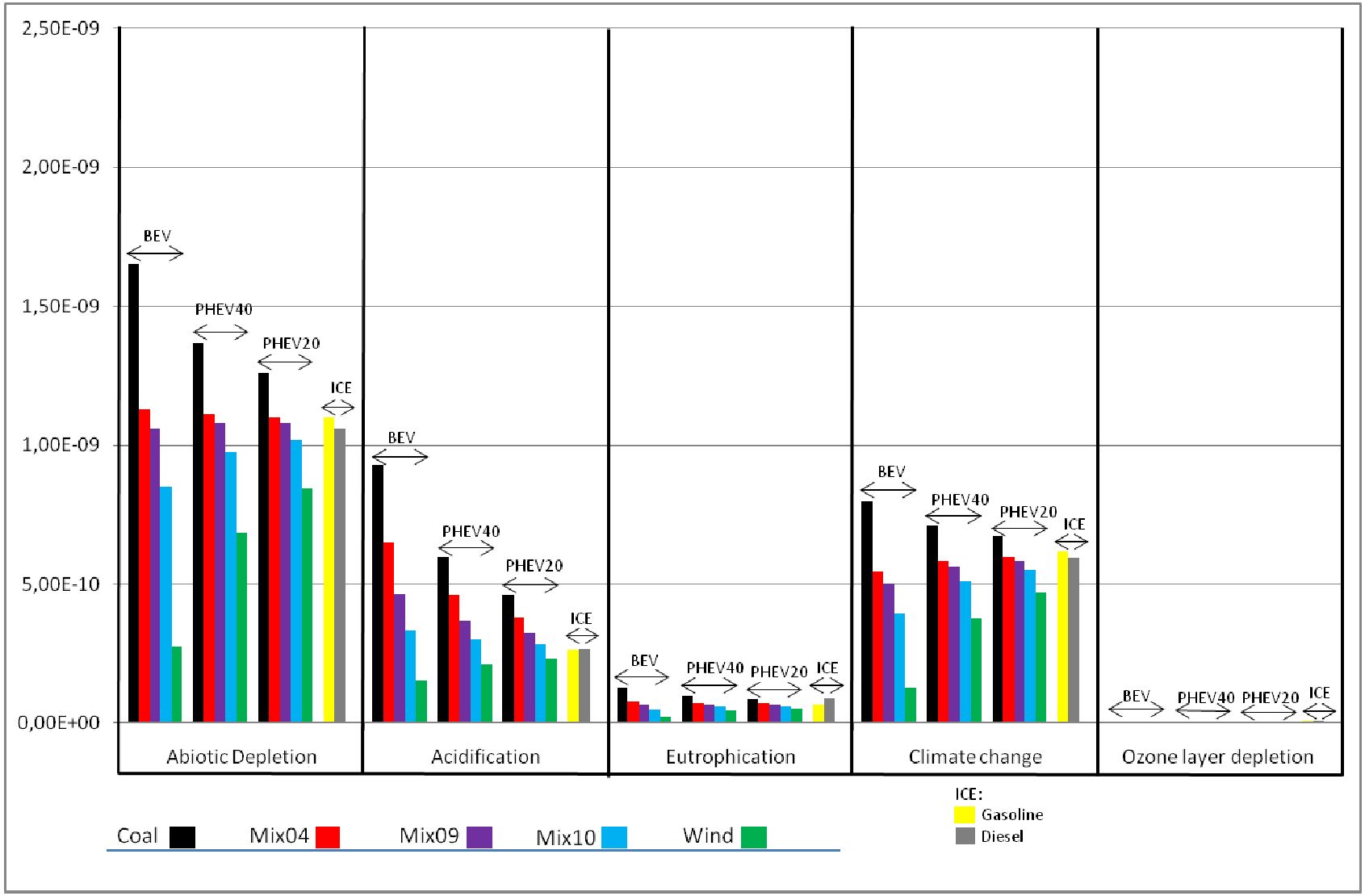
Energy Source	2004 (%)	2009 (%)	2010 (%)	2020 (%)
Coal	29.8	29.9	17.8	15
Oil	10.6	0.8	0.1	0
Natural Gas	21.5	28.8	29.2	45
Hydro	20	15.6	30.1	23.2
PV	9.58E-4	0.3	0.4	0.18
Wind	1.6	15	17.3	16.6
Imported	16.5	9.6	5.1	0
Total	100	100	100	100

Annual variability ↑

GHG intensity (gCO_2 eq/kWh)	**690**	**600**	**469**	**340**

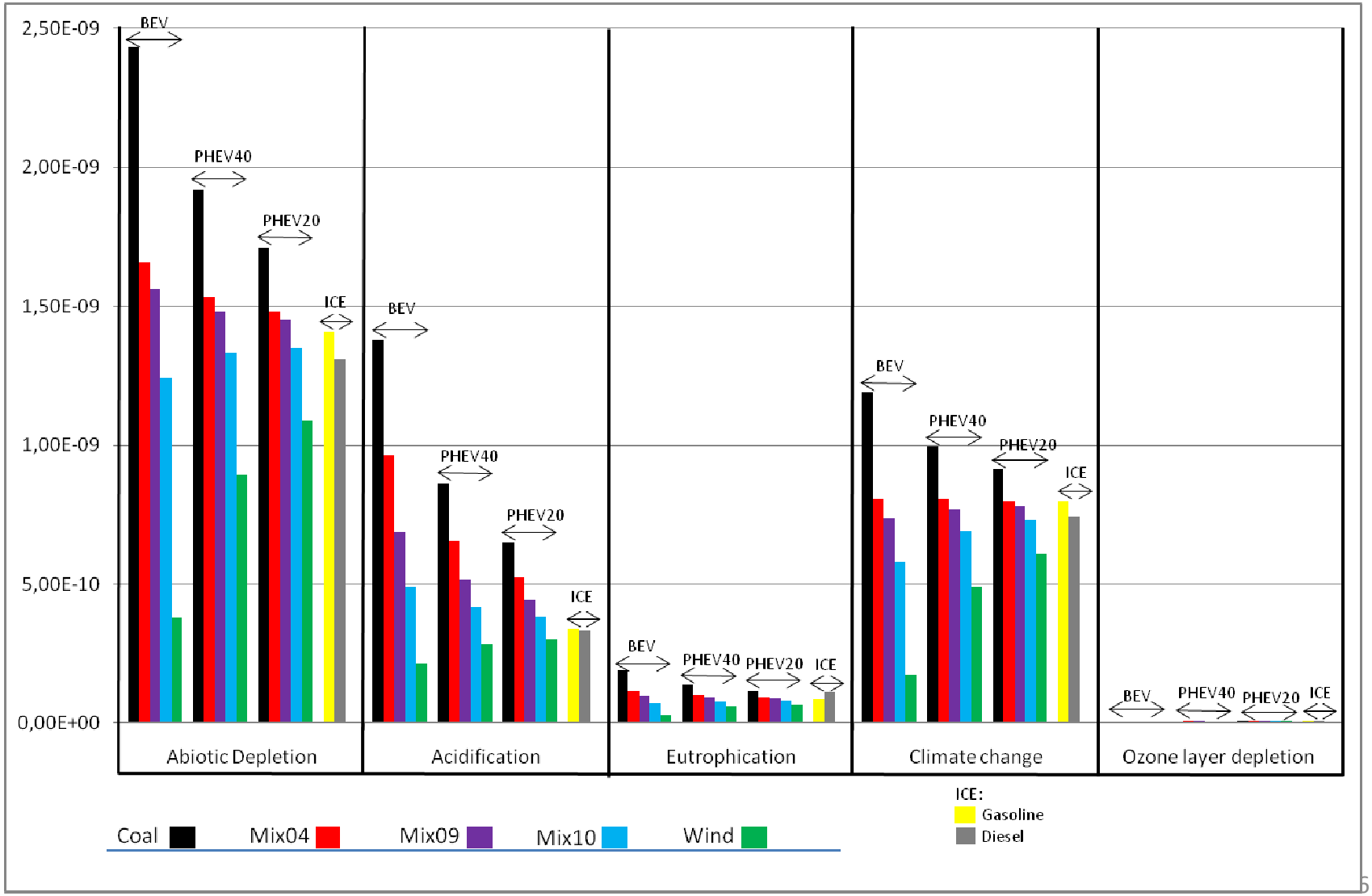
Sources: Portuguese REN (2004, 2008, 2009, 2010);
Ecoinvent (for year 2004)

LCIA normalized results for Urban Vehicles
(200 000 km; CML 2000: World 1995)

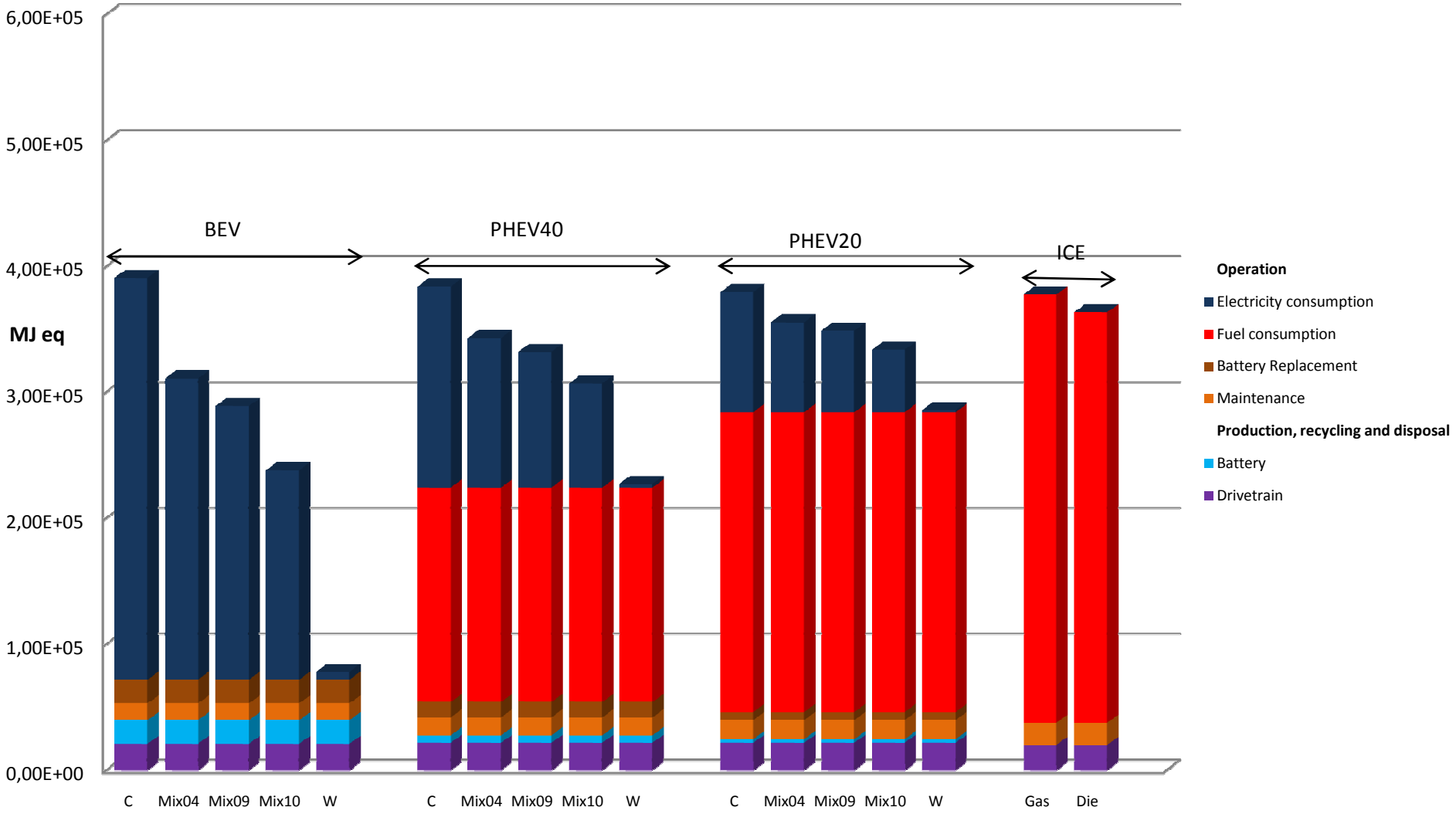


LCIA normalized results for Suburban Vehicles

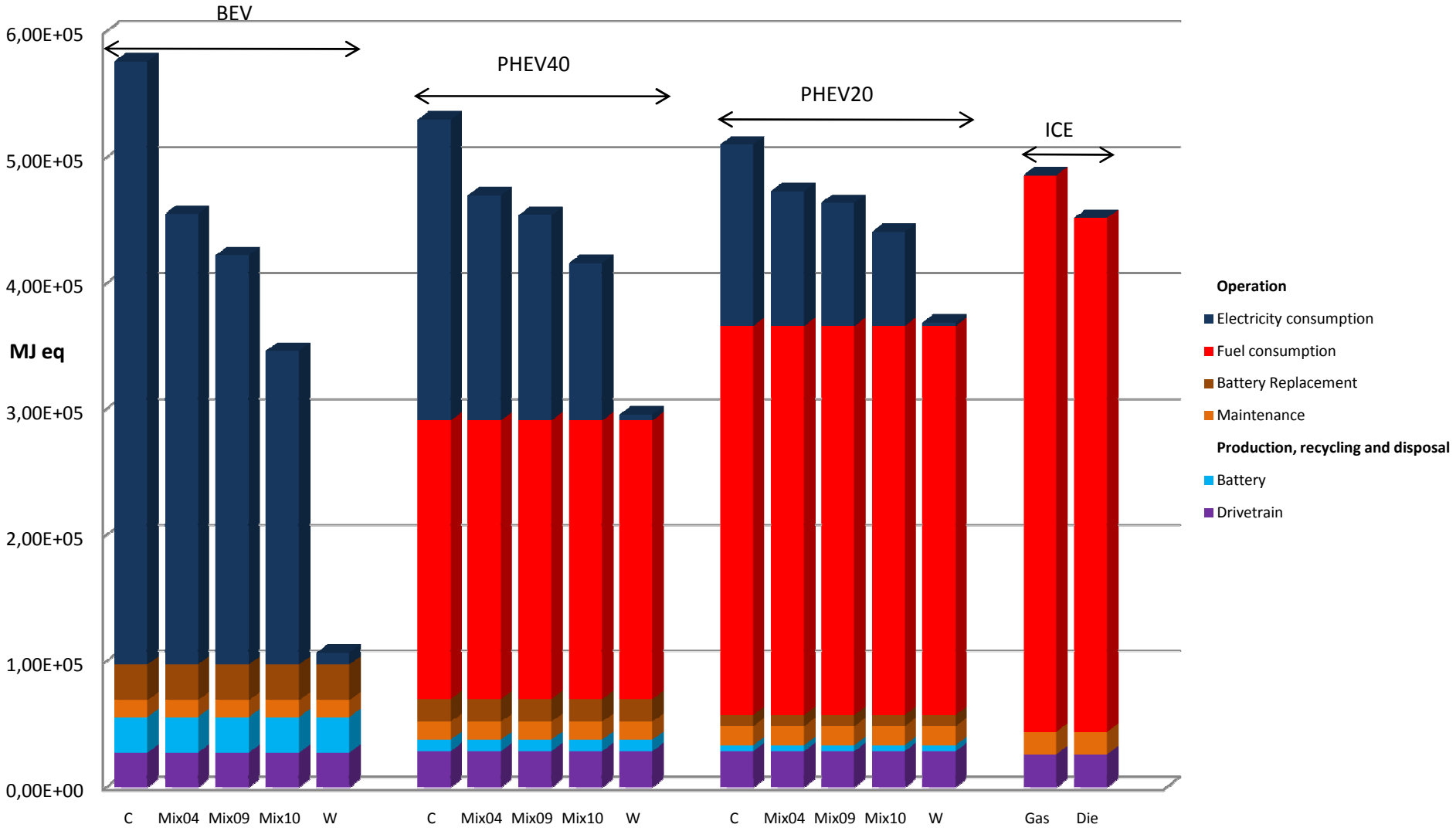
(200 000 km; CML 2000: World 1995)



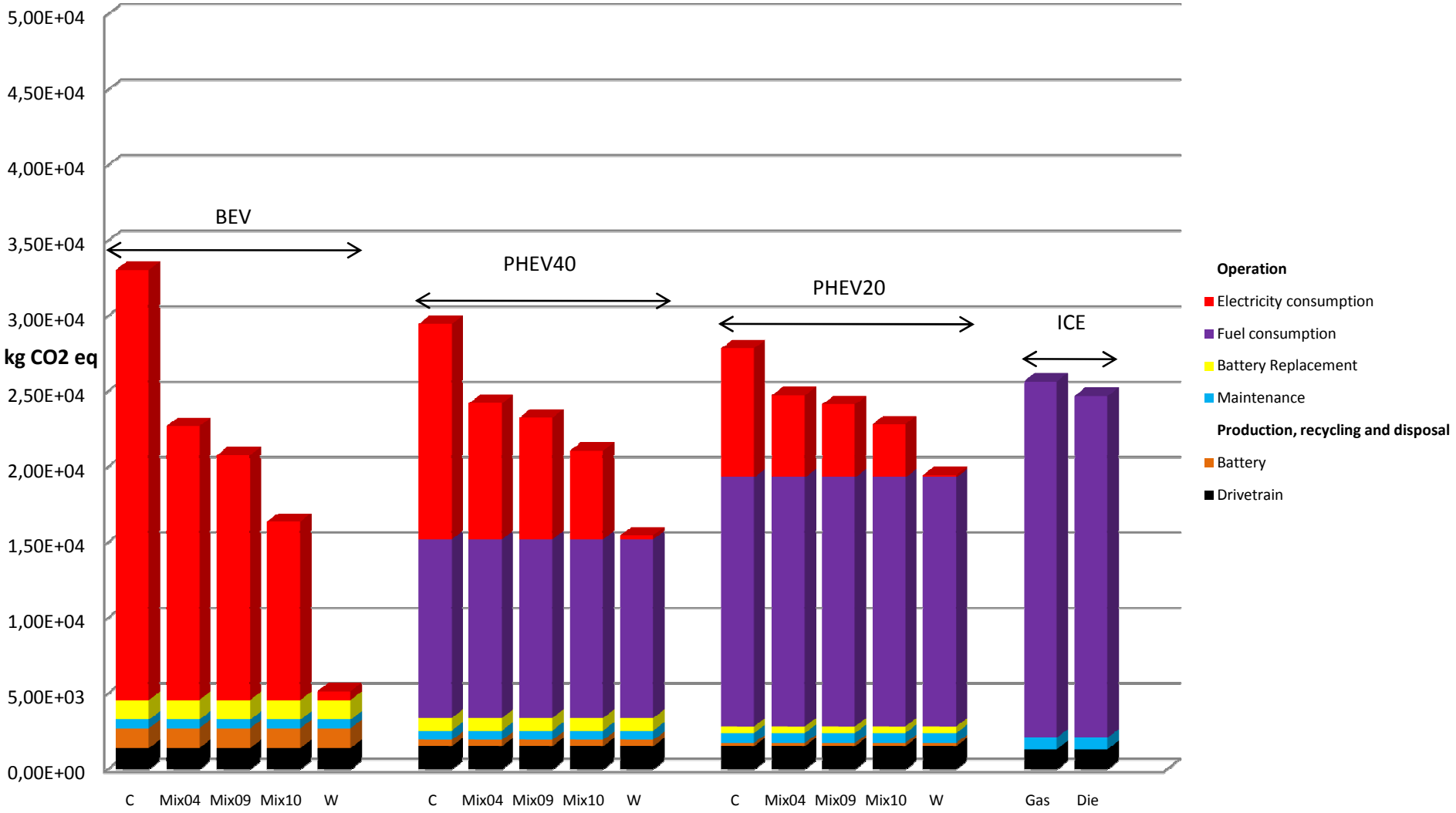
Total Primary fossil energy (CED, MJ eq) of Urban Vehicles (200 000 km)



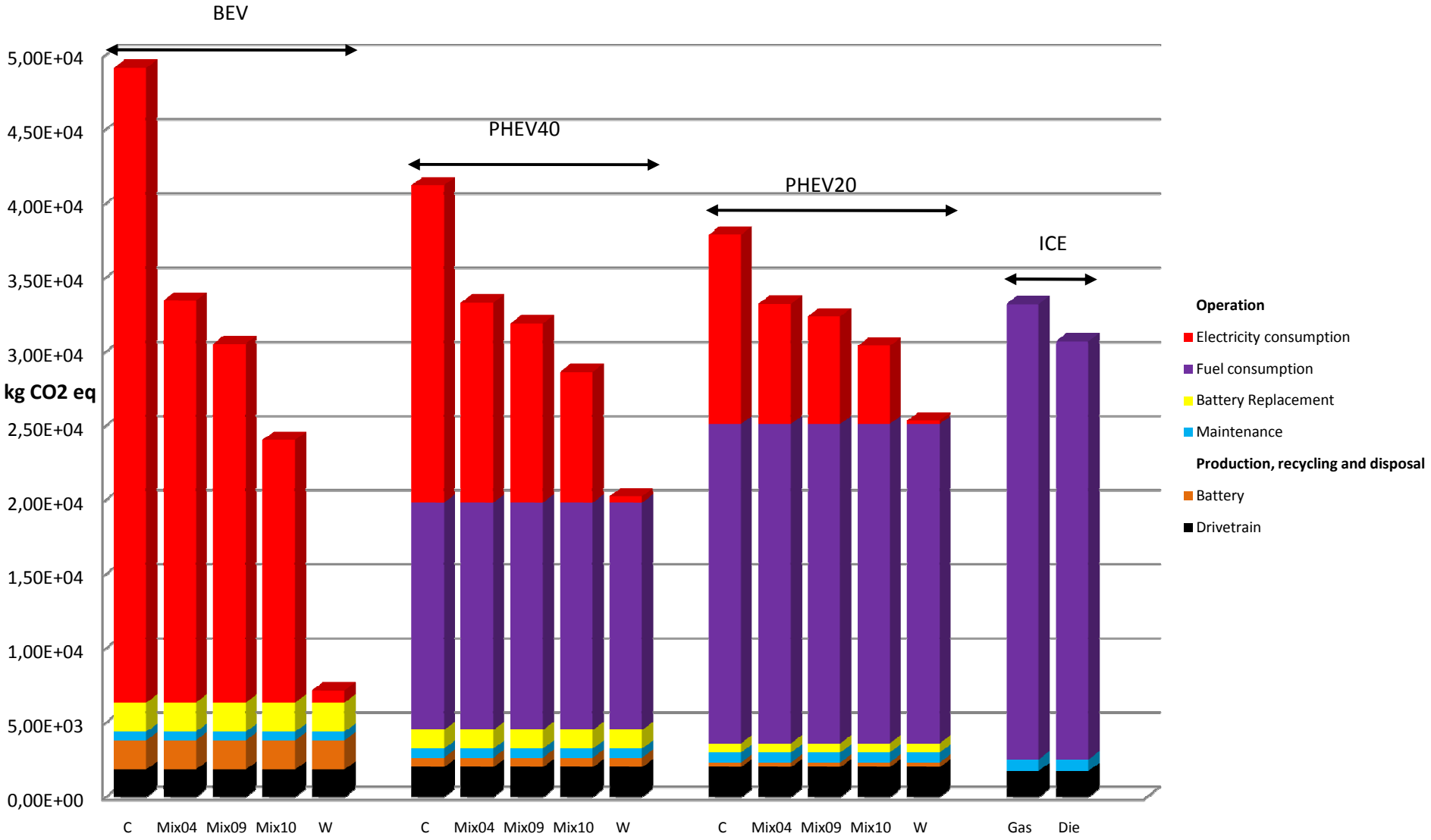
Total Primary fossil energy (CED, MJ eq) of SubUrban Vehicles (200 000 km)



Climate Change (kg CO_{2eq}) of Urban vehicles (200 000 km)



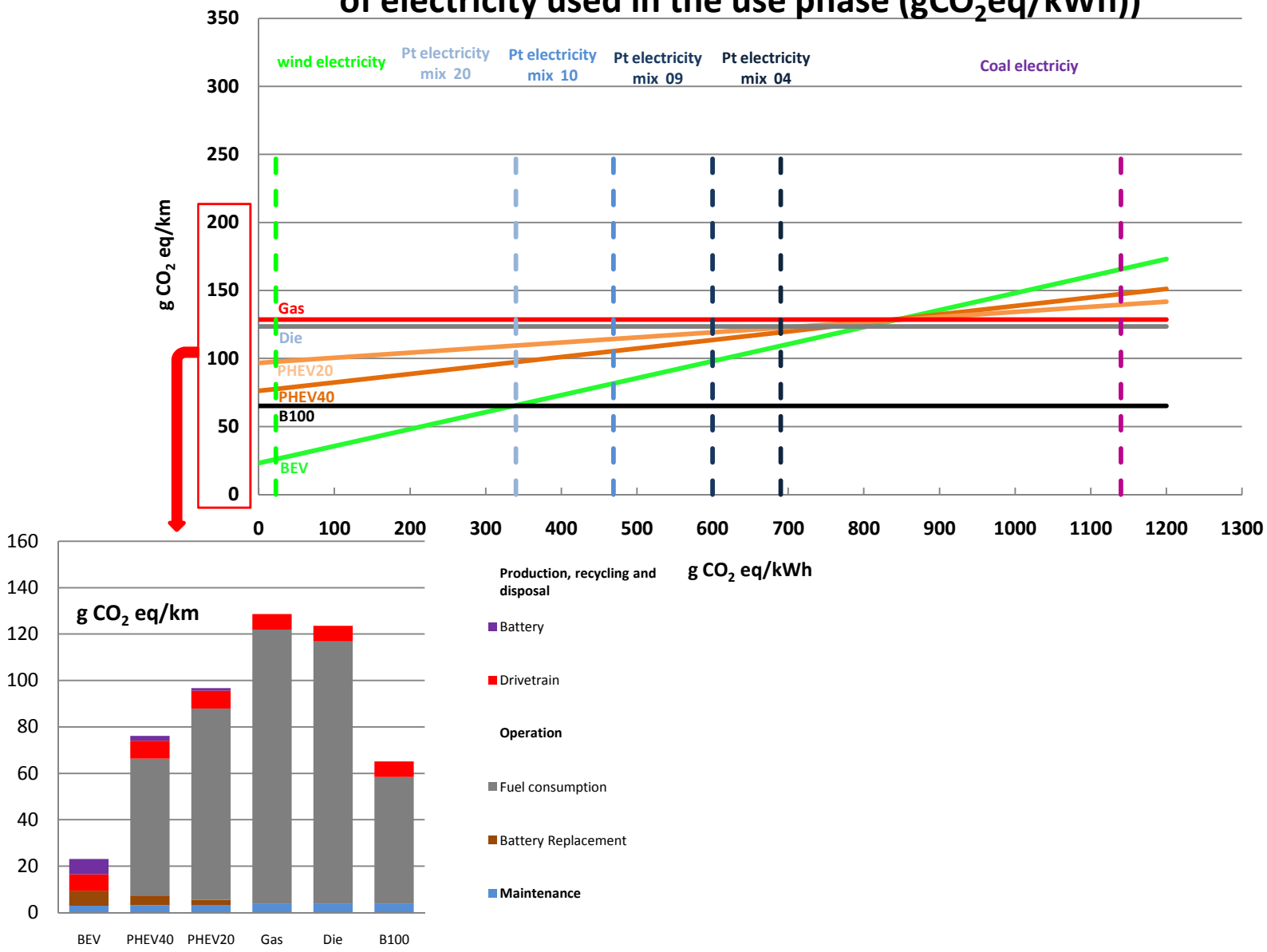
Climate Change (kg CO_{2eq}) of SubUrban vehicles (200 000 km)



Vehicle LC GHG emissions per GHG intensity of electricity used in the operation phase:

Sensitivity Analysis

Urban 200 000 km (20 000 km/year) driven (Vehicle Life-Cycle GHG emissions (gCO_2eq/km) per intensity of electricity used in the use phase (gCO_2eq/kWh))



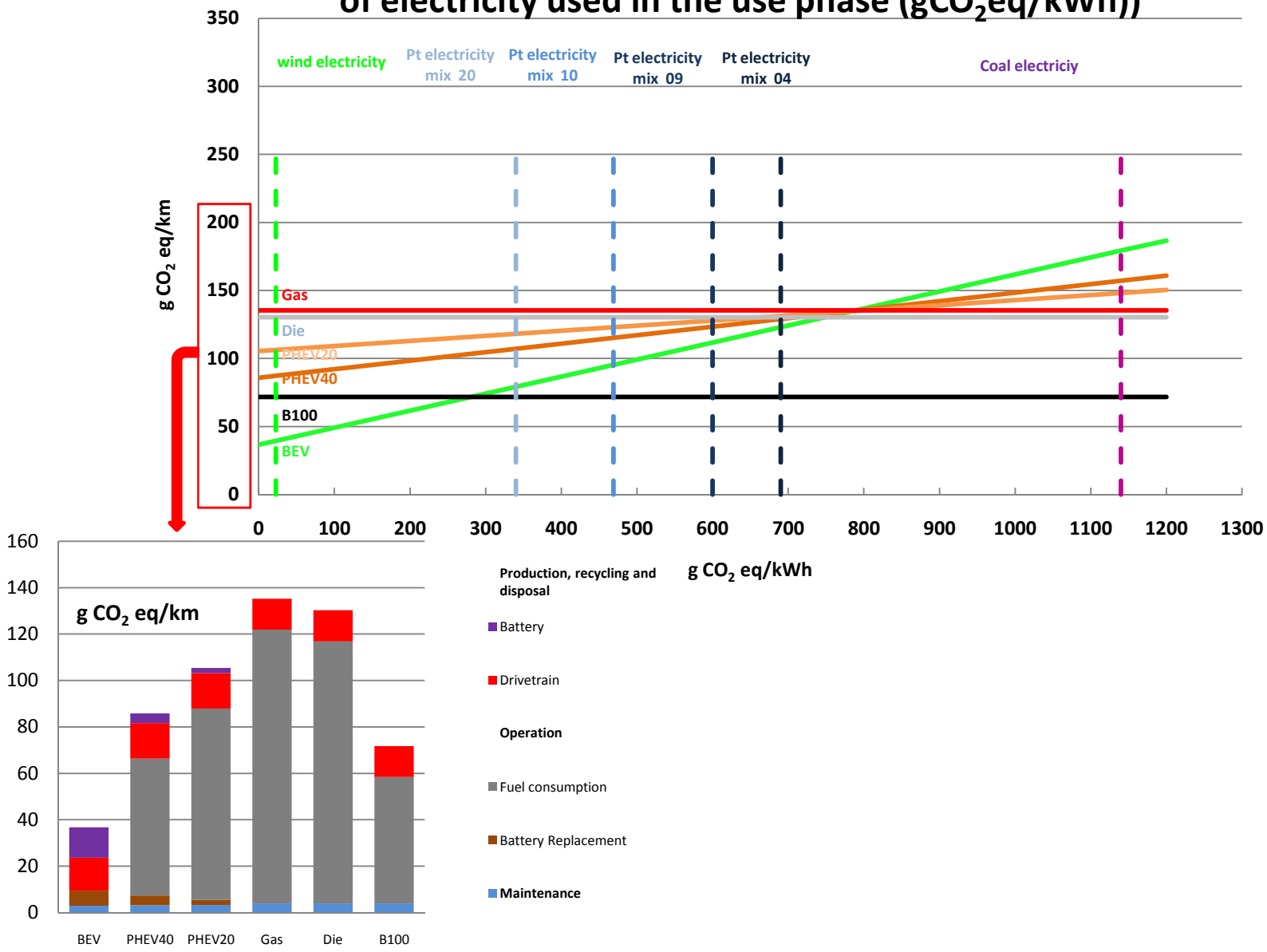
Production, recycling and disposal

- Battery
- Drivetrain

Operation

- Fuel consumption
- Battery Replacement
- Maintenance

Urban 100 000 km (10 000 km/year) driven (Vehicle Life-Cycle GHG emissions (gCO_2eq/km) per intensity of electricity used in the use phase (gCO_2eq/kWh))



Concluding Remarks

- Vehicle operation is the most important phase (energy and environmental) for all vehicles, except with 100% wind based electricity.
- No significantly different results have been obtained for urban and suburban vehicles.
- Electric vehicles (BEV & PHEV) performance is highly dependent of the electricity mix. Urban EVs have an overall GHG performance superior for an electricity intensity below 800 gCO2eq/kWh (700 for suburban).
- The recent evolution of the Portuguese electricity mix is determining for the environmental benefits of EV displacing conventional vehicles.

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Two new Projects (2010- 2013)

•Economic and Environmental Sustainability of Electric Vehicle Systems.

•Capturing Uncertainty in Biofuels for Transportation. Resolving Environmental Performance and Enabling Improved Use

Partners: UC, FCTUC, ADAI-LAETA, INESC, IRS in Portugal and MIT (Materials System Laboratory), in USA

For details: http://www2.dem.uc.pt/CenterIndustrialEcology/