Annex A: Illustration of the independence of the impact from the share of secondary material if EOL credits are accounted for

This example illustrates that the environmental impact – which usually depends strongly on the relative share of primary and secondary material – is independent of this factor if full end-of-life credits are taken into account. The term "full end-of-life credits" refers to credits which reduce the total environmental impact by that extent which would have been caused by the production of primary material (Figure A– approach C).

Table A - Illustration of mass flows entailing end-of-life credits

Assumed secondary material share	25%	50%	75%
Total input material required	10 kg	10 kg	10 kg
Primary input material required	7.5 kg	5.0 kg	2.5 kg
Secondary input material required	2.5 kg	5.0 kg	7.5 kg
Recyclable material after use	10 kg	10 kg	10 kg
Recycled material (efficiency: 90%)	9.0 kg	9.0 kg	9.0 kg
Subtraction for sec. input material	-2.5 kg	-5.0kg	-7.5kg
Remaining recycled material	6.5 kg	4.0 kg	1.5 kg
EOL credits accounting the burden of primary material production	6.5 kg	4.0 kg	1.5 kg
Net burden for primary production	1.0 kg	1.0 kg	1.0 kg

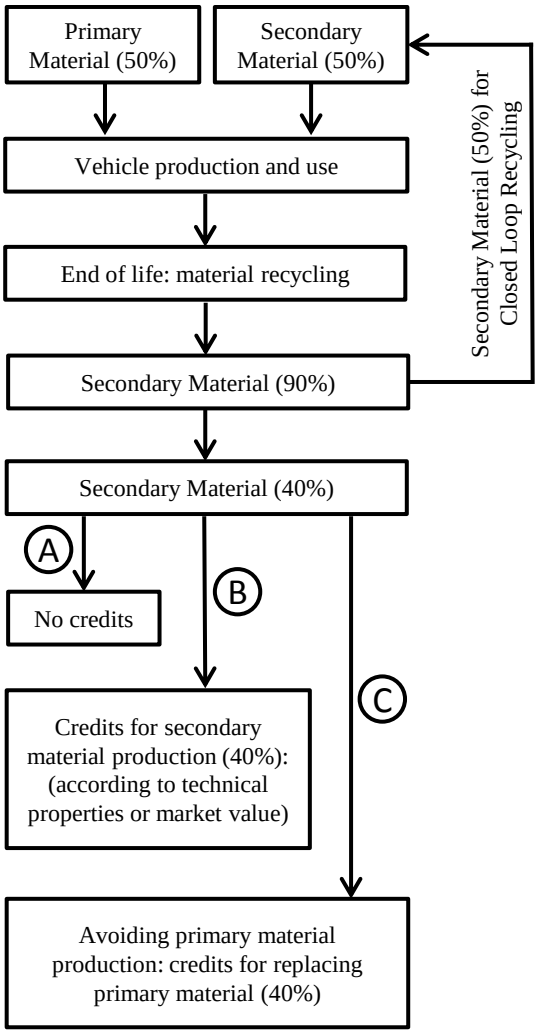

Figure A – End-of-life modeling approaches for 50% secondary material

A product weight of 10 kg and secondary material shares of 25%, 50%, and 75% of the raw material are assumed; this results in required masses of primary and secondary material of 2.5 kg, 5.0 kg, and 7.5 kg, respectively, depending on the amount of secondary material chosen (primary and secondary input material in Table A). At the end of life of the product, the entire material in the product is assumed to be collected and recycled, at which point a certain material loss is registered. In this example, the efficiency for the material recovery is assumed to be 90%, resulting in 9 kg of newly provided secondary material. Depending on the chosen share of secondary material as input material, the amount of secondary material for the production can be subtracted (closed loop recycling Figure A). The surplus secondary material exceeding the amount of closed loop material depends on the chosen scenario and amounts to 1.5 kg, 4.0 kg, and 6.5 kg, respectively. If a full end-of-life credit is taken into account for providing secondary material and thus avoiding production of primary material, one can subtract the end-of-life credits obtained from the initial demand for primary input material. This results in the same value for all three scenarios, which accounts for the material losses during the recycling process and which is independent of the amount of secondary material assumed.

This example demonstrates that the net burden for all three scenarios is the same and thus independent of the amount of secondary material assumed.

Annex B: Assumed weights within the used scenarios

Theoretical weight reductions		Steel (reference)	Aluminum (-40%)	CFRP (-60%)
	Car body weight (kg)	360	216 (-144)	144 (-216)
	Remaining vehicle weight (incl. battery w/o car body) (kg)	1152	1152	1152
	Battery weight (kg)	312	312	312
	Range (km)	120	126	129
	Remaining vehicle weight w/o car body and battery	840	840	840
	Total curb weight (kg)	1512	1368	1296
	Electricity consumption (kWh/100km)	16.7	15.9	15.5
Realistic weight reductions		Steel (reference)	Aluminum (-20%)	CFRP (-30%)
	Car body weight (kg)	360	288 (-72)	252 (-108)
	Remaining vehicle weight (incl. battery w/o car body) (kg)	1152	1152	1152
	Battery weight (kg)	312	312	312
	Range (km)	120	123	124
	Remaining vehicle weight w/o car body and battery	840	840	840
	Total curb weight (kg)	1512	1440	1404
	Electricity consumption (kWh/100km)	16.7	16.3	16.1
Realistic weight reductions and secondary weight reductions (s.w.r.)		Steel (reference)	Aluminum (-20%) + s.w.r.	CFRP (-30%) + s.w.r.
	Car body weight (kg)	360	288	252
	Remaining vehicle weight (incl. battery w/o car body) (kg)	1152	1116	1098
	Battery weight (kg)	312	302	297
	Range (km)	120	120	120
	Remaining vehicle weight w/o car body and battery	840	814	801
	Total curb weight (kg)	1512	1404	1350
	Electricity consumption (kWh/100km)	16.7	16.1	15.8

Annex C: Generic processes from the GaBi professional database and ecoinvent 2.2 used in the LCA models

Material / Process	Quantity / Efficiency	Used dataset	Dataset type	Source
Electricity, Heat Energy and Auxiliary Materials				
Electricity		RER: Strommix, Produktion RER	agg	ecoinvent 2.2
Heat		EU-27: Thermische Energie aus Erdgas	agg	GaBi professional database
deep draw grease		EU-27: Schmierstoffe ab Raffinerie	agg	GaBi professional database
Production of aluminum car body				
primary aluminum		RER: Aluminium, primär, ab	agg	ecoinvent 2.2
secondary aluminum	closed loop recycling (25%)	RER: Aluminium, sekundär, aus altem Schrott, ab Werk	agg	ecoinvent 2.2
hang-on parts	25%	DE: Aluminium Blech Tiefziehen	e-ep	GaBi professional database
body in white – A	75% x 37% = 27.8%	DE: Aluminium Blech Tiefziehen	e-ep	GaBi professional database
body in white – B	75% x 34% = 25.5%	DE: Aluminium Druckgussbauteil	e-ep	GaBi professional database
body in white – C	75% x 29% = 21.8%	RER: Aluminium Extrusionsprofil	t-agg	GaBi professional database
Aluminum: Production scrap and end of life treatment				
Aluminum recycling		RER: Aluminium Recycling inkl. Schrottaufbereitung (2005) EAA	t-agg	GaBi professional database
Credits for secondary aluminum		aluminium, primary, at plant	agg *	ecoinvent 2.2
Production of steel car body				
high stress steel	15%	RER: Stahl-Coil, warmgewalzt worldsteel	agg	GaBi professional database
conventional steel	85%	RER: Stahl-Coil, kaltgewalzt (finished) worldsteel	agg	GaBi professional database
deep drawing	scrap output: 37.5%	DE: Stahl Blech Tiefziehen (mehrstufig)	e-ep	GaBi professional database
New and old steel scrap treatment and recycling				
credits for sec. material from new scrap	95%	Gutschrift für Recycling von Stahlschrott	plan	GaBi professional database
credits for sec. material from old scrap	90.3%	Gutschrift für Recycling von Stahlschrott	plan	GaBi professional database
Carbon fiber production				
PAN fiber		EU-27: Polyacrylnitril Fasern (PAN)	agg	GaBi professional database
epoxy matrix		RER: Epoxydharz, flüssig, ab Werk	agg	ecoinvent 2.2
polyester matrix		RER: Polyesterharz, ungesättigt, ab Werk	agg	ecoinvent 2.2
RTM Recycling and SMC Disposal				
Use of gaseous and liquid pyrolysis yield from RTM	32.5%	EU-27: Abfallverbrennung von Plastik (PET, PMMA, PC) ELCD/CEWEP	t-agg	GaBi professional database
credits for electricity production		RER: Gutschrift für Strommix, Produktion RER	agg*	ecoinvent 2.2
credits for steam production		DE: Prozessdampf aus Erdgas 85%	agg*	GaBi professional database

Incineration of SMC material	60.8%	EU-27: Abfallverbrennung von Plastik (PET, PMMA, PC) ELCD/CEWEP	t-agg	GaBi professional database
Landfill of solids	39.2%	EU-27: Deponie von Glas-/Inertabfall	agg	GaBi professional database
Production and disposal of traction battery				
Traction battery		GLO: Batterie, LiIo, aufladbar, prismatisch, ab Werk	agg	ecoinvent 2.2
Battery disposal		GLO: Entsorgung, Li-Ionen-Batterien, gemischte Technologie	agg	ecoinvent 2.2
Production of remaining vehicle				
Electricity		RER: Strommix, Produktion RER	agg	ecoinvent 2.2
Heat energy		EU-27: Thermische Energie aus Erdgas	agg	GaBi professional database
Aluminum – A		DE: Aluminium Massel Mix	agg	GaBi professional database
Aluminum – B		DE: Aluminium Druckgussbauteil	e-ep	GaBi professional database
Aluminum – C		RER: Aluminiumblech EAA	agg	GaBi professional database
Aluminum – D		RER: Aluminium, Produktionsmix, Gusslegierung, ab Werk	agg	ecoinvent 2.2
Aluminum – E		DE: Aluminium Guss Spanen PE	e-ep	GaBi professional database
Aluminum – F		DE: Aluminium Blech Tiefziehen PE	e-ep	GaBi professional database
Aluminum – G		GLO: Alu Blech Stanzen und Biegen (5% Verl.) PE	e-ep	GaBi professional database
Steel – A		DE: Hochofen Stahl Knüppel / Bramme PE	agg	GaBi professional database
Steel – B		DE: Stahlguss Bauteil legiert	t-agg	GaBi professional database
Steel – C		GLO: Stahl Drehen PE	e-ep	GaBi professional database
Steel – D		RER: Kaltfliesspressen, Stahl, 4 Hübe	agg	ecoinvent 2.2
Steel – E		DE: Stahl-Coil, kaltgewalzt PE	agg	GaBi professional database
Steel – F		DE: Stahl Blech Tiefziehen (mehrstufig) PE	e-ep	
Magnesium		RER: Magnesium, ab Werk	agg	ecoinvent 2.2
Plastic – A		RER: Polypropylen Spritzgussteil (PP) PlasticsEurope	agg	GaBi professional database
Plastic – B		DE: Acrylnitril-Butadiene-Styrol Granulat (ABS) Mix PE	agg	GaBi professional database
Plastic – C		DE: Styrol-Butadien-Kautschuk (SBR) Mix PE	agg	GaBi professional database
Plastic – D		DE: Polycarbonate Granulate (PC) PE	agg	GaBi professional database
Plastic – E		RER: Polyurethan-Hartschaum (PUR) PlasticsEurope	agg	GaBi professional database
Plastic – F		RER: Glasfaserverstärkter Kunststoff, Polyamid, Spritzguss, ab Werk	agg	GaBi professional database
Plastic – G		RER: Polyamid 6 GF30 (PA6 GF30) ELCD/PlasticsEurope	agg	GaBi professional database
Plastic – H		RER: Nylon 6 Granulat (PA 6) ELCD/PlasticsEurope	agg	GaBi professional database
SMC		DE: Sheet Moulding Compound Harzmatte (SMC)	agg	GaBi professional database
Electronics – A		GLO: Elektronisches Bauteil, unspezifisch, ab Werk	agg	ecoinvent 2.2
Electronics – B		GLO: Passives elektronisches Bauteil, unspezifisch, ab Werk	agg	ecoinvent 2.2
On board battery		GLO: Batterie, LiIo, aufladbar,	agg	ecoinvent 2.2

		prismatisch, ab Werk		
Cable – A		GLO: Kabel, Dreipolkabel, ab Werk	agg	ecoinvent 2.2
Cable – B		GLO: Kabel, Datenkabel in Infrastruktur, ab Werk	agg	ecoinvent 2.2
Fan		GLO: Ventilator, ab Werk	agg	ecoinvent 2.2
LEDs		GLO: Leuchtdiode, LED, ab Werk	agg	ecoinvent 2.2
Instruments		GLO LCD Modul, ab Werk	agg	ecoinvent 2.2
Small motors		RER: Elektromotor, Elektroauto, ab Werk	agg	ecoinvent 2.2
Lubricant oil		DE: Schmierstoffe ab Raffinerie	agg	GaBi professional database
Compressed air		GLO: Druckluft 7 bar (niedriger Stromverbrauch)	e-ep	GaBi professional database
Glass		EU-27: Float-Flachglass PE	agg	GaBi professional database
Coat of paint		RER: Acryl-Lack, 87.5% in H2O, ab Werk	agg	ecoinvent 2.2
Water		RER: Wasser (entionisiert) PE	agg	GaBi professional database
Glue		DE: Metallkleber, ab Werk		ecoinvent 2.2
Welding - A		RER: Schweissen, Lichtbogen Aluminium	agg	ecoinvent 2.2
Welding – B		RER: Schweissen, Lichtbogen, Stahl	agg	ecoinvent 2.2
Remaining Vehicle – End of Life: Recycling and Disposal				
Disposal Battery		GLO: Entsorgung, Li-Ionen-Batterien, gemischte Technologie	agg	ecoinvent 2.2
Car Shredder		DE: Autoshredder für Restfahrzeug PE	t-agg	GaBi professional database
Vehicle use phase				
Electricity		RER: Strommix, Produktion RER	agg	ecoinvent 2.2

Abbreviations:

DE: Germany
EU-27: European Union with 27 member states
GLO: Global
RER: Europe
* Process was inverted manually for taking into account end-of-life credits