

Lifetime carbon footprints of cars

Lifetimes are often given as 150,000 kilometres but US examples they may be greater. Average lifetimes are less than 15 years.

Carbon Brief Factchecking (updated 2020)

(See Appendix)

Emissions from cars over a 12 year, 150,000 km lifetime
(tonnes of CO2 equivalent)

Lifetime Emissions	Embodied Carbon	Embodied ex batts	
38.7	6.9	6.9	Average Eu Car
25.2	6.2	5.7	Prius Eco
9.8	9.8	5.7	Nissan Leaf (Norway)
14.1	9.8	5.7	Nissan Leaf (UK)
14.1	10.2	5.7	Tesla 3 UK (US batteries)
17.1	13.2	5.7	Tesla 3 UK (Asian batteries)

Source: Carbon Brief Factcheck:

How electric vehicles help to tackle climate change

<https://www.carbonbrief.org/factcheck-how-electric-vehicles-help-to-tackle-climate-change>

CB Factcheck uses chosen data from Hall and Lutsey

Effects of battery manufacturing on electric vehicle life-cycle greenhouse gas emissions

Note: For Norway, this analysis ignores the fact that excess electricity will be exported to other countries through international interconnectors. Low carbon electricity used in Norway will cause higher carbon electricity to be used in other countries.

Union of Concerned Scientists, (2015)

Cleaner Cars from Cradle to Grave

(Lead author) Rachael Nealer is a Kendall Science, Fellow in the UCS Clean Vehicles Program,

The following estimates are from Figure 7 augmented by some of the text

	Embodied Main	Embodied Batt	Embodied All	Lifetime in distance & tonnes CO ₂ e		1.61 In kms & gms/km
Mid ICE	135,000 54 7.3	135,000 0 0.0	7.3	135,000 Miles 448 gCO ₂ e/m 60.5 t CO ₂ e		217,350 278
Mid BEV	135,000 51 6.9	135,000 17 2.3	9.2	135,000 Miles 220 gCO ₂ e/m 29.7 t CO ₂ e		217,350 137
Full ICE	179,000 53 9.5	179,000 0 0.0	9.5	179,000 Miles 574 gCO ₂ e/m 102.7 t CO ₂ e		288,190 357
Full BEV Tesla S 265-mile	179,000 54.5 9.8	179,000 29 5.2	14.9	179,000 Miles 270 gCO ₂ e/m 48.3 t CO ₂ e		288,190 168

Quote:

"where BEVs are sold today, [they] are 51 percent lower than the comparable midsize gasoline car, thereby saving 29 tons of CO₂e."

So Lifetime emissions for ICE vehicle ~60 tonnes CO₂e

and lifetime emissions for a BEV ~30 tonnes CO₂e.

(This must refer to MID vehicles.)

Paper in Science Direct (2019)

[The role of electric vehicles in near-term mitigation pathways and achieving the UK's carbon budget](#)

Graeme Hill et al. , School of Engineering, Future Mobility Group, Newcastle University

[Ricardo's(2011)] report found that production in the UK of a standard mid-sized ICE will result in emissions of 5.6 tCO₂ , whilst production of an equivalent sized EV will result in CO₂ emissions of 8.8 tCO₂ .

Quote:

The exact amount of CO₂ emissions from production of both ICEs and EVs is a matter of some dispute with a wide range of possible figures depending both on the assessment methodology used (e.g. “bottom up” versus “top down”) and the assumptions made in the production stage [41,42]. However, the most extensive work on battery production [43] provides a value of 150–200 kgCO₂ /kWh. This leads to an excess of 4.2 tCO₂ for a 24 kWh battery (the battery size for the initial Nissan Leaf models which would correspond to an 80–100km range) which, assuming the same CO₂ production emissions for the vehicle body and reduced production emissions for the EV drive train, will lead to a value similar to that shown in the earlier work by Ricardo.

Low Carbon Vehicle partnership (2018)

Lifecycle emissions from cars, Annex 1: LowCVP Press release

Vehicle Whole Life Carbon Emissions Analysis

	Estimated lifecycle emissions	Proportion of emissions in production	Estimated embodied carbon
	tonnes CO2e	%	tCO2e
Standard gasoline vehicle	24	23%	5.6
Hybrid vehicle	21	31%	6.5
Plug-in hybrid vehicle	19	35%	6.7
Battery electric vehicle	19	46%	8.8

Based upon a 2015 vehicle in use for 150,000 kilometres using 10% ethanol blend and 500g/KWH grid electricity.

Top-down & bottom-up estimates for batteries

[Effects of battery manufacturing on EV life-cycle greenhouse gas emissions](#)

Authors: Hall&Lutsey

Compares estimates of the CO₂e emissions due to battery manufacture.

The paper notes bottom up and top down estimates.

This allows embodied CO₂e in batteries can be estimated.

Bottom up method of Dunn et al.

Car	Avg CO ₂ e per Kwh of battery	Kwh in Battery	Embodied carbon in battery	
Nissan Leaf	40	24	1.0	tCO ₂ e
Tesla 3LR	40	75	3.0	tCO ₂ e

Top down method of Ambrose & Kendal

Car	Avg kg CO ₂ e / Kwh of battery	Kwh in Battery	Embodied carbon in battery	
Nissan Leaf	344	24	8.3	tCO ₂ e
Tesla 3LR	344	75	25.8	tCO ₂ e

The differences may be exaggerated because Ambrose & Kendal based their study on batteries made in Asia but Dunn et al. based their study on batteries made in the USA. It seems unlikely that all of the eight fold difference is accounted for by the difference in geography.

Kgs CO₂e in making batteries from Table 1 in Hall & Lutsey

Source	Kgs CO ₂ e per Kwh	Ratio	Made where	Method
Dunn et al.	30-50	1.0	US	bottom-up
Kim et al.	140	3.5	?	bottom-up
Majeau-Bettez et al.	200-250	5.6	?	both
Ambrose & Kendall	194-494	8.6	East Asia	top-down

How bad are bananas, Mike Berners-Lee (2010)

Embodied CO2e in manufacturing cars

Model	Description	Emmissions in Manufacturing		Weight tonnes
Citroen C1	Basic spec	6	tCO2e	0.85
Ford Mondeo	Medium spec	17	tCO2e	1.76
Land Rover Discovery	Top of Range	35	tCO2e	2.22
Assumed lifetime kms		150000	Kilometers	

Spread over lifetime kms this is

Citroen C1	Basic spec	40	gCO2e/km
Ford Mondeo	Medium spec	113	gCO2e/km
Land Rover Discovery	Top of Range	233	gCO2e/km

Well to Wheel emissions from Which (2019)

Car CO2 Emissions

Citroen C1	Basic spec	146	gCO2e/km
Ford Mondeo	Medium spec	180	gCO2e/km
Land Rover Discovery	Top of Range	271	gCO2e/km
Assumed lifetime kms		150000	Kilometers

Lifetime in use

Citroen C1	Basic spec	21.9	tCO2e
Ford Mondeo	Medium spec	27.0	tCO2e
Land Rover Discovery	Top of Range	40.7	tCO2e

Adding the lifetime emissions of Which to Berners Lees' emodied values:

Total lifetime emissions (Berners Lee + Which)

Lifetime embodied plus in use emissions

Citroen C1	Basic spec	27.9	tCO2e
Ford Mondeo	Medium spec	44.0	tCO2e
Land Rover Discovery	Top of Range	75.7	tCO2e

Arthur D. Little (2016)

Battery Electric Vehicles vs. Internal Combustion Engine Vehicles: A United States-Based Comprehensive Assessment

Authors: John Brennan & Timothy Barder of Arthur D. Little

	Embodied Main tCO2e	Embodied Batt tCO2e	Embodied 2nd Batt tCO2e	Embodied All tCO2e	Lifetime Distance Miles	Lifetime Emissions tCO2e	Lifetime Distance in kms
Compact ICEV	6.4	0	0	6.4	150,685	62.1	242,603
Compact BEV	7.3	4.5	4.1	15.9	118,650	47.6	191,027
Mid-Size ICEV	6.4	0.0	0.0	6.4	150,685	68.9	242,603
Mid-Size BEV	7.7	6.8	5.9	20.4	118,650	55.8	191,027

PE International (2013)

Life Cycle CO2e Assessment of Low Carbon Cars (2020-2030) For the Low Carbon Vehicle Partnership

Authors: Ehri GbegBaje-Das and Dr Sandy Smith

This study in 2013 ave estimates for the embodied carbon for different categories of cars as they would be in 2020 based on an extrapolation of factors in 2012.

The embodied carbon was broken down by the parts of the car. This helps in testing estimates for embodied carbon in BEVs - where bottom-up accounting is used.

The **glider** refers to all parts of a vehicle except the engine, transmission and power train.

	Total Embodied tCO2e	Embodied % for engine	Embodied % for glider	Embodied % for Lead batt	Embodied % for batt	Embodied % for e motor	Embodied % for p Electric	Embodied % for Other
Case 2020								
ICEV	6.15	14	72	1	0	0	0	13
BEV	8.98	0	39	0	48	3	4	6

	Total Embodied tCO2e	Embodied tCO2e engine	Embodied tCO2e glider	Embodied tCO2e Lead batt	Embodied tCO2e batt	Embodied tCO2e e motor	Embodied tCO2e p Electric	Embodied tCO2e Other
Case 2020								
ICEV	6.15	0.86	4.43	0.06	0.00	0.00	0.00	0.80
BEV	8.98	0.00	3.50	0.00	4.31	0.27	0.36	0.54

Note that the estimates for the glider for ICEVs and BEVs are very similar.

Applying PE's percentages to Berners-Lee estimate for the Ford Mondeo.

	Total Embodied tCO2e	Embodied % for engine	Embodied % for glider	Embodied % for Lead batt	Embodied % for batt	Embodied % for e motor	Embodied % for p Electric	Embodied % for Other
B-L's Ford Mondeo	17.0	14	72	1	0	0	0	13

	Total Embodied tCO2e	Embodied tCO2e engine	Embodied tCO2e glider	Embodied tCO2e Lead batt	Embodied tCO2e batt	Embodied tCO2e e motor	Embodied tCO2e p Electric	Embodied tCO2e Other
B-L's Ford Mondeo	17.0	2.4	12.2	0.2	0.0	0.0	0.0	2.2

Applying PE's percentages gives an estimate of the embodied carbon in the glider in

Berners-Lees measure of the Ford Mondeo as **12.2 tonnes CO2e**. This compares with the estimate of **4.43 tonnes CO2e** for PE's 2020 estimate for the glider on an ICEV.

The typical models in the ICEVs of PE were: Ford Focus, VW Golf, Renault Megane. Their average weight was given as 1.24 tonnes. This is low compared to today's figures. Weights given on internet in tonnes (april 2020)

	low	avge low	high	avge high	Average
Ford Focus	1.28		1.59		
VW Golf	1.21	1.27	1.62	1.62	1.44
Renault Megane	1.31		1.65		

	low	avge low	high	avge high	Average
Ford Mondeo	1.696		1.826		1.76

Ford Mondeo compared to PE'e ICEV = **122%**

Increasing PE's ICEV's by 22% gives the following estimates for a Mondeo's embodied carbon:

The typical models in the ICEVs of PE were: Ford Focus, VW Golf, Renault Megane. Their average weight was given as 1.24 tonnes. The Ford Mondeo is 22% heavier at 1.76 tonnes. Increasing PE's ICEV's by 22% gives the following estimates for a Mondeo's embodied carbon:

	Total Embodied tCO2e	Embodied tCO2e engine	Embodied tCO2e glider	Embodied tCO2e Lead batt	Embodied tCO2e batt	Embodied tCO2e e motor	Embodied tCO2e p Electric	Embodied tCO2e Other
PE's	122%							
Mondeo'	7.5	1.1	5.4	0.1	0.0	0.0	0.0	1.0

These calculations are crude but they estimate that Berners-Lees estimate of the embodied carbon in a Ford Mondeo is over twice the (2020 projected) estimates of PE international.

For the 'glider', this crude reconstruction of PE's estimate of its embodied carbon makes it 6.8 tonnes less in than that of Beners-Lee.

PE's estimates probably used bottom-up methodology. Berners-Lee's estimates are top-down methodology.

Adding the in-use lifetime emissions from Which to the embodied...

From PE & Which Lifetime tCO2e	From PE (uprated) Embodied tCO2e	From Which In-use tCO2e
34.5	7.5	27.0

Transport & Environment (2020)

[How clean are electric cars?](#)

T&E's analysis of electric car lifecycle CO₂ emissions

Author: Lucien Mathieu

Associated with this article Transport & Environment have published a tool to calculate the lifetime CO₂ emissions of electric cars, petrol car, and diesel cars.

The following table has used the tool to estimate CO₂ emissions after a distance of 150,000 kms.

Car emissions after 150,000 kms, as tonnes CO₂

150k	36	5.4	Band B (Renault Clio)
150k	40	6.7	Band C (VW Golf)
150k	47	7.8	Band D (VW Passat)
150k	50	9.4	Band E (Audi A7)
150k	15	8.4	Band B (Renault Clio electric?)
150k	18	10.5	Band C (Nissan Leaf)
150k	21	12.6	Band D (Tesla 3)
150k	25	15.2	Band E (Tesla S)

Increasing these by 25% to give estimates in CO₂ equivalent:

Car emissions after 150,000 kms, as tonnes CO₂e

150k	45	6.8	Band B (Renault Clio)
150k	50	8.4	Band C (VW Golf)
150k	59	9.8	Band D (VW Passat)
150k	63	11.8	Band E (Audi A7)
150k	19	10.5	Band B (Renault Clio electric?)
150k	23	13.1	Band C (Nissan Leaf)
150k	27	15.8	Band D (Tesla 3)
150k	31	19.0	Band E (Tesla S)

ICE vehicles' lifetime emissions

Lifetime kms	Lifetime tCO2e	Embodied tCO2e		
150k	39	6.9	Average Eu Car	CB
150k	25	6.2	Prius Eco	CB
217k	61	7.3	Mid ICE	UCS
288k	103	9.5	Full ICE	UCS
150k	24	5.6	Standard gasoline vehicle	LowCVP
150k	28	6	Citroen C1	B-L Which
150k	44	17	Ford Mondeo	B-L Which
150k	76	35	Land Rover Discovery:Top range	B-L Which
243k	62	6.4	Compact ICEV	ADL
243k	69	6.4	Mid-Size ICEV	ADL
150k	29	6.2	ICEV (Mid-Size)	PE (2020)
150k	35	7.5	Ford "Mondeo"	PE Which
150k	45	6.8	Band B (Renault Clio)	Trans Env
150k	50	8.4	Band C (VW Golf)	Trans Env
150k	59	9.8	Band D (VW Passat)	Trans Env
150k	63	11.8	Band E (Audi A7)	Trans Env

Electric Vehicles' lifetime emissions

Lifetime kms	Lifetime tCO2e	Embodied tCO2e		
150k	14	9.8	Nissan Leaf (UK)	CB
150k	14	10.2	Tesla 3 UK (US batteries)	CB
150k	17	13.2	Tesla 3 UK (Asian battrs)	CB

217k	30	9.2	Nissan Leaf (40 kWh)	UCS
288k	48	14.9	Tesla Model S (75 kWh)	UCS
150k	19	8.8	Battery electric vehicle	LowCVP
243k	48	15.9	Compact BEV	ADL
243k	56	20.4	Mid-Size BEV	ADL
150k	19	8.4	Band B (Renault Clio electric?)	Trans Env
150k	23	10.5	Band C (Nissan Leaf)	Trans Env
150k	27	12.6	Band D (Tesla 3)	Trans Env
150k	31	15.2	Band E (Tesla S)	Trans Env

(40kWh Nissan Leaf has 84 Mile range, 75 Kwh Tesla Model S7 has 249 mile range.)

Notes

Embodied
method

**	CB	Carbon brief (2020)	Bottom-up
***	UCS	Union of Concerned Scientists (2015)	Bottom-up
	LowCVP	Low Carbon Vehicle Partnership	Bottom-up
*	B-L W	Berners Lee + Which	Top-down
	ADL	Arthur D Little	Bottom-up
	PE (2020)	PE International estimates for 2020 cars	Bottom-up
	PE Which	PE Int uprated for Ford Mondeo	Bottom-up
	TransEnv	Transport & Environment	Bottom-up

*** The top down methods of Berners Lee (and Ambrose&Kendal for batteries) give significantly higher estimates of embodied carbon. There are no studies in the above for the embodied carbon in electric vehicles using top down methods.**

**** When considering embodied carbon without the batteries The CB figures are identical for both Evs: Nissan Leaf (40kwh) and Tesla 3 (75Kwh) at 5.7 tonnes CO2e. Is that odd?**

***** Gasoline cars considered by UCS were Hyundai Equus,**

Chrysler 300 Rwd, Mercedes S 550 RWD, Porche Panamara,
Aldi A8. Average weight 2.1 tonnes.

UCS give embodied carbon ex batteries of 9.5 tonnes CO2e.

Berners Lee's top-down analysis gives embodied carbon
of a Land Rover Discovery as 35 tonnes CO2e.

It's weight 2.3 tonnes, similar to the UCS gasoline cars.

Appendix Carbon Brief Factchecking

How electric vehicles help to tackle climate change

Model	CO2e Batteries	CO2e Tailpipe	CO2e Fuel Cycle	CO2e Embodied Main	Life dist kms 150000	CO2e Lifetime Emissions	CO2e embodied Batt+Main	
Av Eu Car	0	165	47	46	150000		46	gm/km
	0	165	212	258	38700000		6900000	gms
	0.0			6.9		39	6.9	tCO2e
Prius Eco	3	99	28	38	150000		150000	kms
	3	102	130	168	25200000		6150000	gms
	0.5			5.7		25	6.2	tCO2e
Nissan Leaf 40kWh (Norway)	27	0	0	38	150000		150000	kms
	27	27	27	65	9750000		9750000	gms
	4.1			5.7		10	9.8	tCO2e
Nissan	27	0	29	38	150000		150000	kms
							65	gm/km

Leaf 40kWh (UK)	27	27	56	94	14100000	5.7	14	9750000	9.8	gms tCO2e
Tesla 3 UK, US batteries	30	0	26	38	150000	150000	14	150000	68	kms gm/km
	30	30	56	94	14100000	5.7	14	10200000	10.2	gms tCO2e
Tesla 3 UK, Asian batts	50	0	26	38	150000	150000	17	150000	88	kms gm/km
	50	50	76	114	17100000	5.7	17	13200000	13.2	gms tCO2e

Carbon Brief assume lifetimes as 12 years and 150,000 kms