



clear

Research

White Paper:

Segway i2 Personal Transporter Carbon Footprint Calculation

Ben Hedley – Clear, the carbon offset company
10th December 2008



Table of Contents

1	Introduction	2
2	Calculation	3
2.1	Sources	3
2.1.1	Electricity:	3
2.1.2	Range / Power Consumption	3
2.2	Calculation	3
2.3	Conclusion	4
3	Comparable modes of transport	5
3.1	Private Transport	5
3.2	Public Transport	6
3.3	Sources of Comparison	6
4	Notes	7
4.1	About Clear, the Carbon Offset Company	7
4.2	About Segway	7
4.3	About this report	7

1 Introduction

This White Paper calculates the g/km equivalent carbon footprint figure for the Segway i2 personal transporter, recharged from a typical UK mains power supply.

A figure of **16.6 g/km** is calculated based on real world experience, rather than manufacturer claims and compared to typical g/km figures for other substitutional modes of transport.

A simple guide to the i2, published by Segway PT is shown below:



2 Calculation

2.1 Sources

2.1.1 Electricity:

UK National Grid Rolling Average = 0.53702 kgCO₂e per KWH (2008 Guidelines to DEFRA's GHG Conversion Factors)

2.1.2 Range / Power Consumption

Isidore Margaronis commutes daily from Notting Hill (W8) to Piccadilly Circus over a variety of terrain from smooth paths to potholed roads.

Isidore is an experienced Segway PT owner, having owned several, ridden approximately 10,000 miles and he suggests that a less experienced rider might ride more conservatively, potentially travelling further on a single charge. Isidore's Segway is not new, the batteries having completed approximately 110 charge cycles, with a typical life expectancy on this type of battery of 1000 cycles. He notes that typically Segway PT performance reduces after 18/18.5 miles as the machine switches into reduced power mode for safety.

As an experiment, Isidore fully charged his i2 Segway PT and travelled a distance of **19.9 miles** before the Segway PT indicated that it was approaching safety shutdown. He then recharged the device, measuring a power input of **0.99 kwh** for a full capacity charge.

Official Segway PT figures suggest a range of between 16 and 24 miles on a complete (1 to 1.04 kwh) charge, We have taken the average here of 20 miles, and a figure of 1 kwh to be a reasonable mid-point.

2.2 Calculation

	I Margaronis	Segway Official								
<u>DISTANCE</u>										
Distance (miles)	19.90	20.00	miles	<table border="1"> <tr><td> </td><td>inputs</td></tr> <tr><td> </td><td>factors</td></tr> <tr><td> </td><td>calculations</td></tr> </table>		inputs		factors		calculations
	inputs									
	factors									
	calculations									
	1.60934	1.60934	miles to km							
Distance (km)	32.03	32.19	km							
<u>POWER</u>										
Complete Charge	0.99	1.00	Kwh	Source: DEFRA						
kg CO ₂ / Kwh	0.53702	0.53702								
kg CO ₂	0.53	0.54								
g CO ₂	531.65	537.02								
	16.60	16.68	g/km							

2.3 Conclusion

Agreeing closely with manufacturer's figures, **16.6 g/km** appears to be a reasonable real-world measurement for the carbon footprint of a Segway PT in the UK*. Interestingly the official figures are slightly more pessimistic than those achieved in a real world test. Clear's estimate of the realistic accuracy of figures would be +/- 2 g/km of CO₂.

If we were to look in purely carbon terms at the g/km, we could use the comparison with a petrol car. For a petrol-powered car to have the same footprint would require a fuel economy of 394 mpg (miles per gallon).

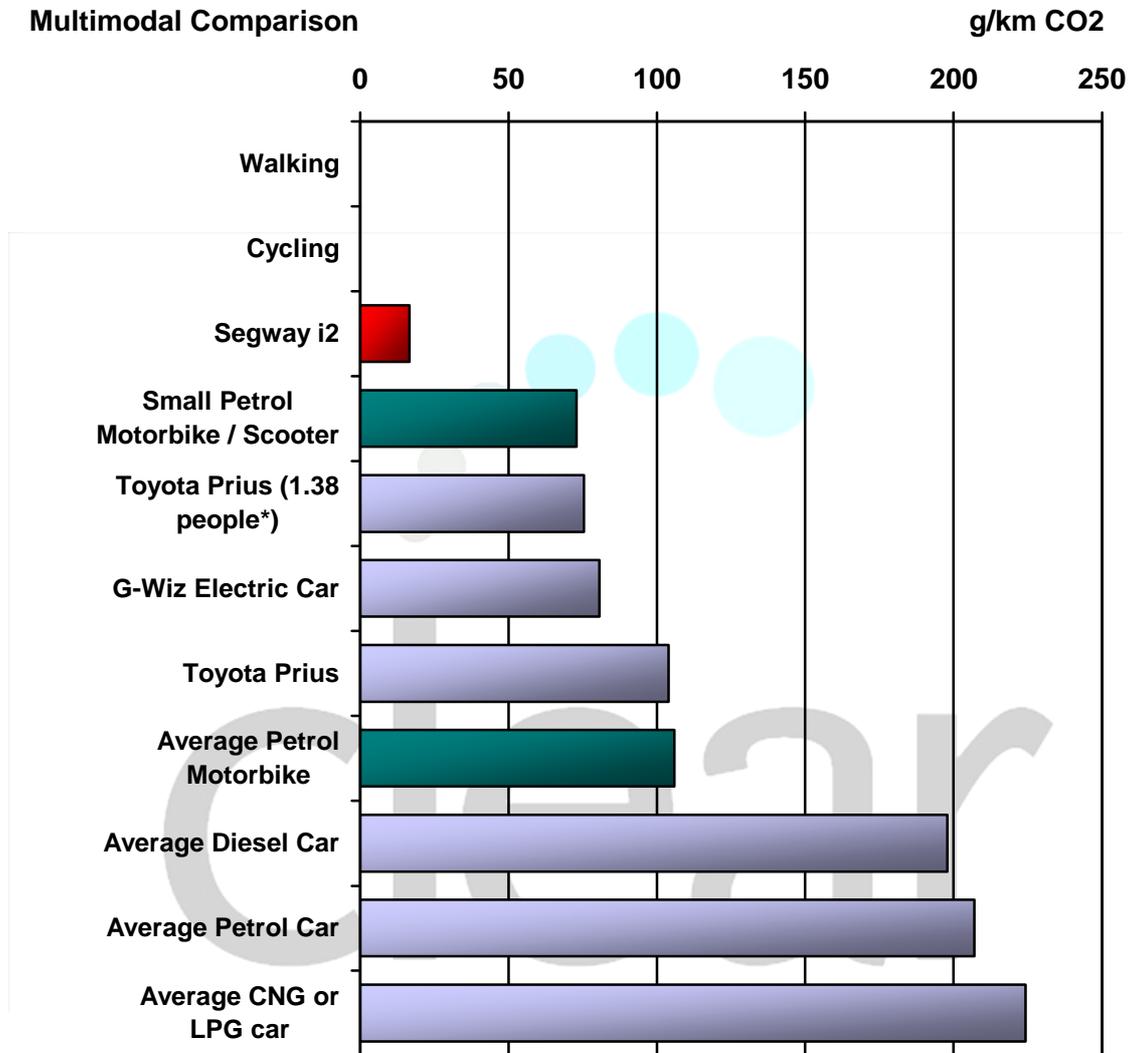
*Obviously this will be different for other countries which have different mixes of electricity generation and hence kgCO₂e figures.



3 Comparable modes of transport

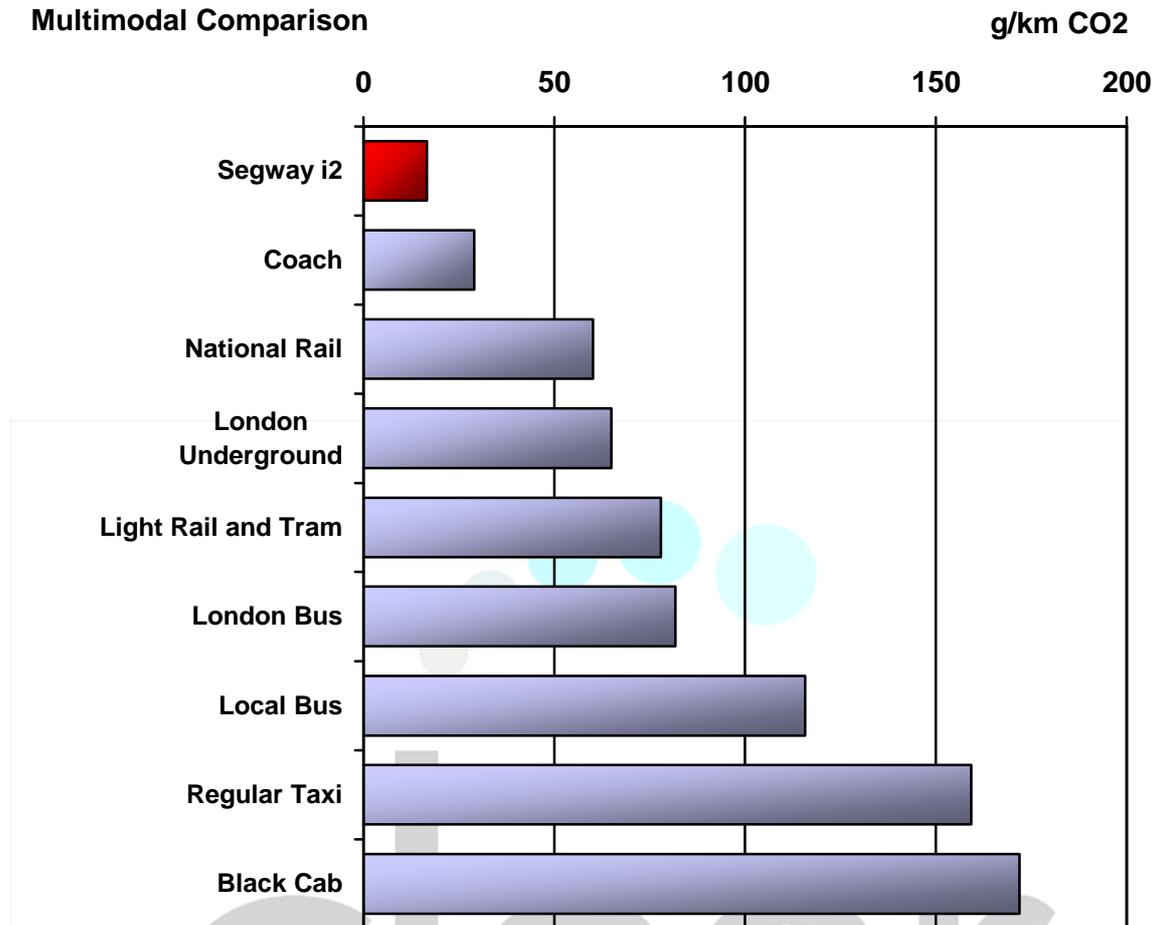
3.1 Private Transport

As a form of private transport in terms of CO2 g/km, the Segway PT is only beaten by cycling or walking (which are currently assumed to be 0 g/km):



- 1.38 people is the average central London vehicle occupancy during peak hours in 2007.
- All other modes assume a single occupant.

3.2 Public Transport



It should also be pointed out that distance travelled between the same two points can change dependent on mode. A bus route from A to B may be a greater distance than a direct route by taxi for example.
All figures assume average occupancy as per DfT assumptions.

3.3 Sources of Comparison

The source for all figures are the average factors provided in:
2008 Guidelines to Defra's GHG Conversion Factors
Annexes updated April 2008

- Private transport figures developed by AEA Energy & Environment and agreed with Department for Transport (2007)
- Public Transport figures developed by Department for Transport, Transport for London and AEA Energy & Environment, 2008

Average occupancy from 2007 London Travel Report – TfL – average occupancy of cars into London during peak hours = 1.38.

G-Wiz figure is based on a battery capacity of 9.66kwh, and a range of 40 miles charged on average UK mains electricity
(www.goinggreen.co.uk/store/content/gwiz_techspec)

4 Notes

4.1 About Clear, the Carbon Offset Company

Clear is the first carbon offsetting company in the UK to be compliant with the standards for the UK Government's Quality Assured Offsetting Scheme. As part of this scheme, Clear has had the accuracy of all carbon calculators independently audited by AEA group (www.aeat.co.uk/) on behalf of DEFRA / DfT.

Clear specialises in research into new methods of carbon foot-printing, and this white paper has been produced as part of that ongoing research.

The author of this report is Ben Hedley *MEng, MA (Cantab)*, Operations Director of Clear. He holds two degrees in Manufacturing Engineering from Cambridge University, specialising in Thermodynamics and Mechanics.

Clear currently have no commercial relationship with Segway Inc, and this white paper has been created independently of any direct input from Segway Inc.

More information on Clear is available at: www.clear-offset.com

4.2 About Segway PT

The Segway i2 is a two-wheeled, self-balancing electric vehicle invented by Dean Kamen. It is produced by Segway Inc. of New Hampshire, USA. The name "Segway" is a homophone of "segue" (a smooth transition, literally Italian for "follows"). PT is an initialism for personal transporter while the old suffix HT was an initialism for human transporter.

Computers and motors in the base of the device keep the Segway PT upright when powered on with balancing enabled. Users lean forward to go forward, lean back to go backward, and turn by using a "Lean Steer" handlebar, leaning it left or right. Segway PTs are driven by electric motors at up to 20 kilometres per hour (12 mph). Gyroscopic sensors are used to detect tilting of the device which indicates a departure from perfect balance. Motors driving the wheels are commanded as needed to bring the PT back into balance.

The Segway is powered by lithium ion batteries, recharged from a domestic electricity source.

More information on Segway is available at: www.segway.com

4.3 About this report

No part of this report may be reproduced or published without prior permission of Clear, the carbon offset company (support@clear-offset.com)