How green was my vehicle?

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We investigated how much air pollution is created by an electric car using electricity generated by an EFW incinerator. We also compared the results with (a) the electric car powered by electricity from a conventional power station and (b) a very similar petrol-powered version of the same car.

The car chosen was the electric Peugeot 208, with maximum power 100 kW, and a petrol version, with maximum power 96 kW, as shown in Table 1. For the petrol version, the technical specifications [2] state the emissions per km of specific pollutants. For the electric version, they state the amount of energy used per km, known as the "electric energy consumption". The carbon dioxide emissions and the electric energy consumption are given as (narrow) ranges, rather than single values.

The electric energy consumption can be converted to emissions per km if we know the amount of emissions per unit of electricity generated (by an incinerator or power station). To calculate this, we chose seven established incinerators in England and obtained their emissions from the 2019 Pollution Inventory [1]. The amounts of electricity generated and exported were taken from each incinerator's annual performance report. We used the exported (not generated) amount to calculate the emissions per unit of electricity, as shown in Table 2. For some incinerators, the particulates emissions do not appear in the Pollution Inventory; these incinerators were excluded. Carbon monoxide emissions do not appear in the Pollution Inventory for almost any incinerator, so these were derived from the average pollutant concentrations reported in the incinerators' annual performance reports, as shown in Table 3.

The calculated emissions per unit of electricity vary widely across the seven incinerators, as shown in Table 2. A possible reason may be that two of the incinerators export thermal energy as well as electricity. However, neither of these incinerators have the highest emissions per unit of electricity, for any pollutant, so it seems that the additional thermal energy exported does not increase emissions. For each pollutant, we took the median (of the seven values) as a typical value, representative of incinerators in general. The median, minimum, and maximum are shown in Table 4.

Finally, the values of emissions per km (Table 5) were calculated from Table 4 by multiplying by the vehicle's electric energy consumption. Because the electric energy consumption is given as a range, the minimum and maximum values were used to calculate the minimum and maximum emissions, respectively. The average (midpoint) was used to calculate the median value of emissions per km.

For comparison, the same calculations were applied to the Drax power station, with emissions data taken from the Pollution Inventory, as shown in Tables 6 and 7. Drax was chosen because it is the UK's largest power station and one of the largest polluters. In 2019, almost all of its electricity was generated from wood burning (13.4 TWh wood vs. 0.6 TWh coal).

Results

The results using the median values are plotted in Figure 1. Figure 2 plots the minimum (dark colour) and maximum (light colour) values.

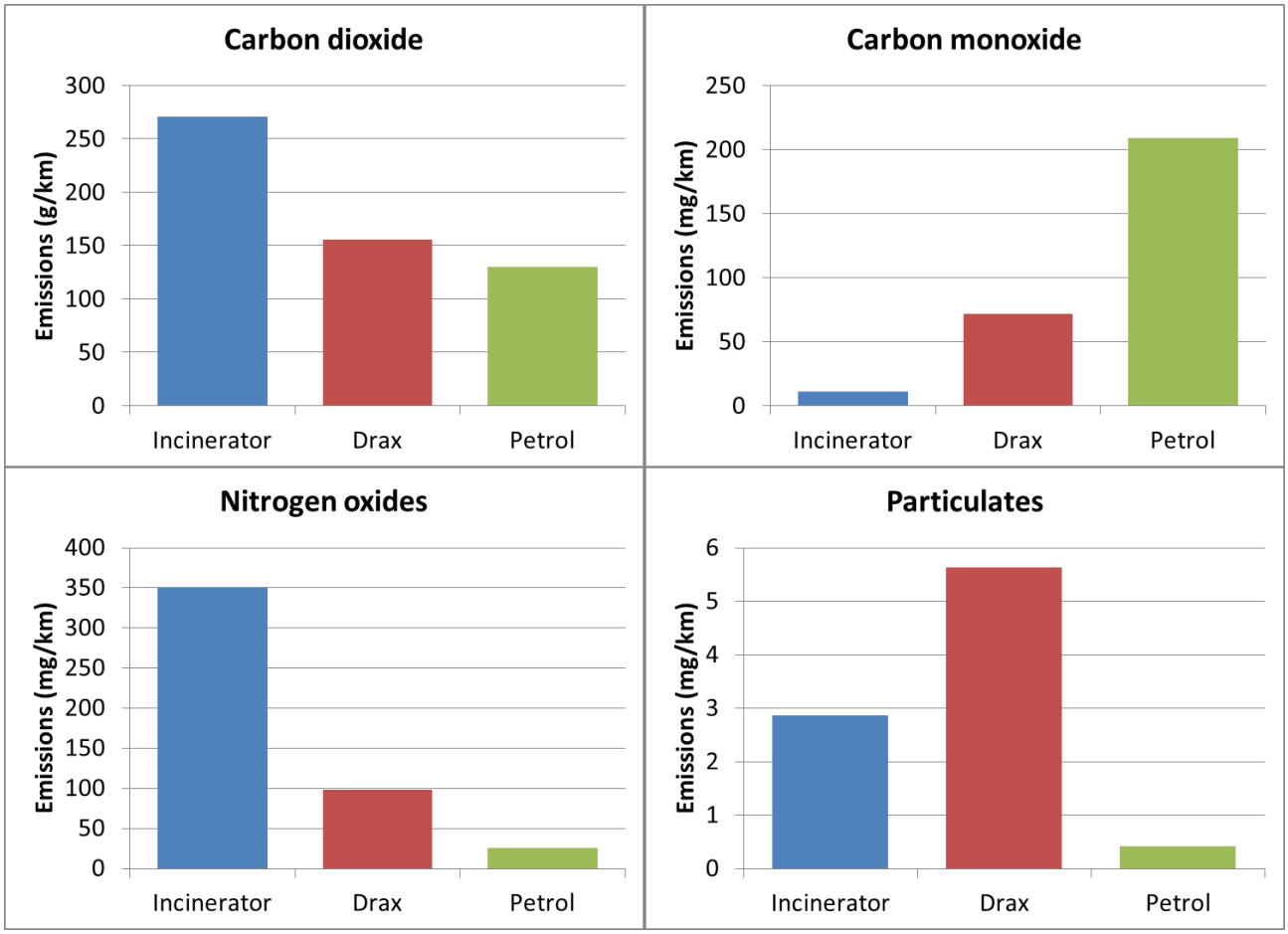

Figure 1. Comparison of emissions of vehicle powered by electricity from an incinerator, electricity from Drax, and petrol. Median values are plotted.

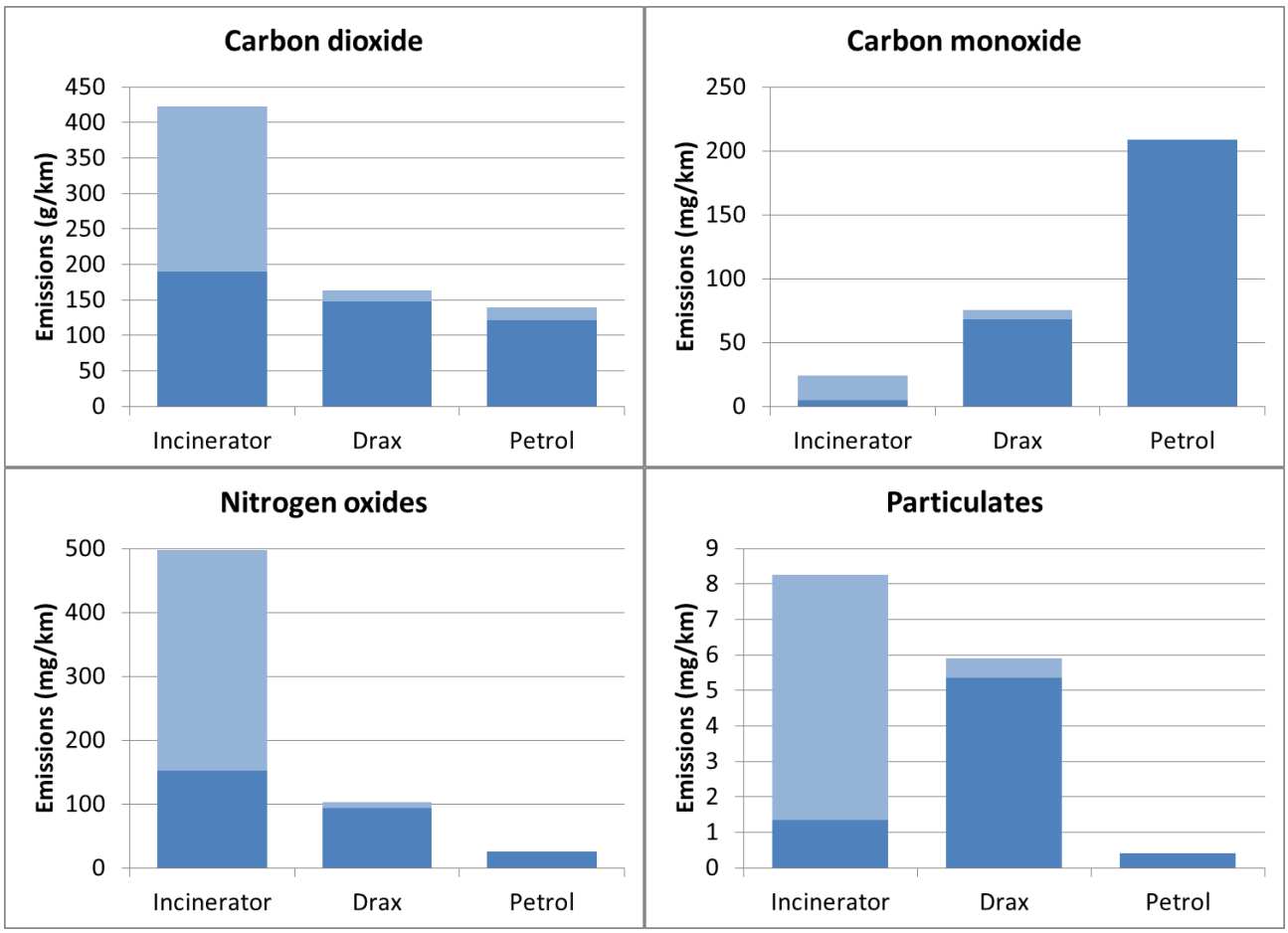

Figure 2. Comparison of emissions of vehicle powered by electricity from an incinerator, electricity from Drax, and petrol. Minimum and maximum values are plotted.

Tables

Table 1. Electric energy consumption data for Peugeot 208 electric vehicle and emissions (per km) data for similar petrol vehicle [2].

1.2L PureTech 130 EAT8 S&S 8-speed automatic petrol			
Emissions	Carbon dioxide	g/km	121–139
	Carbon monoxide	mg/km	208.7
	Total hydrocarbons	mg/km	19.9
	Nitrogen oxides	mg/km	26
	Particulates	mg/km	0.42
Electric 50 kWh 136			
Electric Energy Consumption		Wh/km	159–176

Table 2. Emissions of pollutants from seven incinerators for 2019 (from Pollution Inventory [1]), amount of electricity exported (from each incinerator's annual performance report), and the calculated emissions per unit of electricity exported. Note: the carbon monoxide emissions were derived from other data (Table 3).

			SELCHP	Sheffield	SERC	Newhaven	Greatmoor	Portsmouth	Marchwood
Thermal exported?			Yes	Yes	No	No	No	No	No
2019 emissions	Carbon dioxide	kg	361665000	207592160	329987000	200391000	228660000	190082000	190082000
	Carbon monoxide	kg	9523	10889	16655	3642	11897	10767	16473
	Nitrogen oxides	kg	566632	243541	264400	254936	329804	223620	186350
	Particulates	kg	3470	3169	5500	2078	8761	1343	1033
Exported electricity		MWh	223798	105927	276668	121490	186636	79106	122894
Emissions per Wh	Carbon dioxide	mg/Wh	1616	1960	1193	1649	1225	2403	1547
	Carbon monoxide	mg/Wh	0.0426	0.1028	0.0602	0.0300	0.0637	0.1361	0.1340
	Nitrogen oxides	mg/Wh	2.5319	2.2991	0.9557	2.0984	1.7671	2.8268	1.5163
	Particulates	mg/Wh	0.01551	0.02992	0.01988	0.01710	0.04694	0.01698	0.00841

Table 3. Derivation of emissions of carbon monoxide from seven incinerators for 2019. Carbon monoxide emissions (italics) were calculated by scaling the nitrogen oxides emissions, from the Pollution Inventory [1], using the average emission concentrations of carbon monoxide and nitrogen oxides reported in each incinerator's annual performance report.

			SELCHP	Sheffield	SERC	Newhaven	Greatmoor	Portsmouth	Marchwood
Average concentration	Carbon monoxide	mg/Nm^3	3	7.2875	8.42	2.7	6.37	8.33	13.95
	Nitrogen oxides	mg/Nm^3	178.5	163.0	133.7	189.0	176.6	173.0	157.8
2019 emissions	Carbon monoxide	kg	*9523*	*10889*	*16655*	*3642*	*11897*	*10767*	*16473*
	Nitrogen oxides	kg	566632	243541	264400	254936	329804	223620	186350

Table 4. Emissions of pollutants from incinerators per unit of electricity exported. The columns show the minimum, median, and maximum over the seven incinerators using 2019 data on emissions and electricity export.

		Minimum	Median	Maximum
Carbon dioxide	mg/Wh	1193	1616	2403
Carbon monoxide	mg/Wh	0.0300	0.0637	0.1361
Nitrogen oxides	mg/Wh	0.9557	2.0984	2.8268
Particulates	mg/Wh	0.00841	0.01710	0.04694

Table 5. Emissions per km by the electric vehicle using electricity from incinerators. The minimum values (mg/km) are the product of the minimum values (mg/Wh) from Table 4 and the minimum electric energy consumption of the vehicle from Table 1 (159 Wh/km). The maximum values were multiplied by the maximum electric energy consumption (176 Wh/km). The median values were multiplied by the average electric energy consumption (167.5 Wh/km).

		Minimum	Median	Maximum
Carbon dioxide	g/km	189.6	270.7	422.9
Carbon monoxide	mg/km	4.77	10.68	23.96
Nitrogen oxides	mg/km	151.9	351.5	497.5
Particulates	mg/km	1.336	2.865	8.262

Table 6. Emissions of pollutants from Drax power station for 2019 (from Pollution Inventory [1]), amount of electricity exported (from the Drax annual report), and the calculated emissions per unit of electricity exported.

2019 emissions	Carbon dioxide	kg	12992850000
	Carbon monoxide	kg	5979000
	Nitrogen oxides	kg	8172000
	Particulates	kg	470450
Exported electricity		MWh	14000000
Emissions per Wh	Carbon dioxide	mg/Wh	928
	Carbon monoxide	mg/Wh	0.4271
	Nitrogen oxides	mg/Wh	0.5837
	Particulates	mg/Wh	0.03360

Table 7. Emissions per km by the electric vehicle using electricity from Drax power station. The minimum, “median”, and maximum values were calculated by multiplying the values (mg/Wh) from Table 6 by the minimum (159 Wh/km), average (167.5 Wh/km), and maximum (176 Wh/km) electric energy consumption of the vehicle from Table 1.

		Minimum	“Median”	Maximum
Carbon dioxide	g/km	147.6	155.5	163.3
Carbon monoxide	mg/km	67.90	71.53	75.17
Nitrogen oxides	mg/km	92.8	97.8	102.7
Particulates	mg/km	5.343	5.629	5.914

References

1. 2019 Pollution Inventory Dataset. Environment Agency. https://environment.data.gov.uk/portalstg/home/item.html?id=0ddaf1d806b348168d1c36108c0945f5
2. Peugeot 208 Technical Specifications v8.3. November 2021. https://www.peugeot.co.uk/content/dam/peugeot/uk/b2c/buy/price-and-spec-guides/pdfs/208-price-spec-guide.pdf