Office of the Prime Minister's Chief Science Advisor
Kaitohutohu Mātanga Pūtaiao Matua ki te Pirimia

Title:

INTERN RESOURCES: CO_2 emissions and energy consumption year 2018 - Resources

Author:

OPMCSA - Intern - Odile Smits

Output type:
PDF

Pages:
9 pp

Date:
Apr-20

Language:
English

Review:
Not peer reviewed

Versions

Record number:	*Version:*	*Date V1 created:*	*Date:*	*Printed version*
PMCSA-20-23-02	V2	18-May-20	23-Apr-21	N

Archive page link:
https://dpmc.govt.nz/our-programmes/special-programmes/prime-ministers-chief-science-advisor-archives/archive/gerrard-2018-2021

Notes:
Internal report to the PMCSA

CO_2 emissions and energy consumption year 2018

Odile Smits
Intern with the Office of the Prime Minister's Chief Science Advisor

Contents

CO_2 emissions and energy consumed by the New Zealand vehicle fleet in the year 2018

The total of the CO_2 emissions and energy consumption by fleet type during the year 2018 is calculated using the 2018 statistics of the New Zealand vehicle fleet provided by the Ministry of Transport.[1]

The number of vehicles, the distance driven per vehicle type, combined with average fuel consumption and corresponding carbon intensity, allows us to calculate how much energy was consumed and how much CO_2 was produced (Figure 1).[2]

[1] https://www.transport.govt.nz/mot-resources/vehicle-fleet-statistics/
The carbon intensity per km driven for light passenger vehicles (both diesel and petrol) is obtained from this report (Table 9.2 a,b), since the results of the WTW analysis of light passenger vehicles (calculated in the previous section), were for a specific vehicle. The carbon intensity for vehicles other than light passenger vehicles is obtained by scaling with the respective average fuel consumption.

[2] Tables used to generate the figures are in the Appendix.

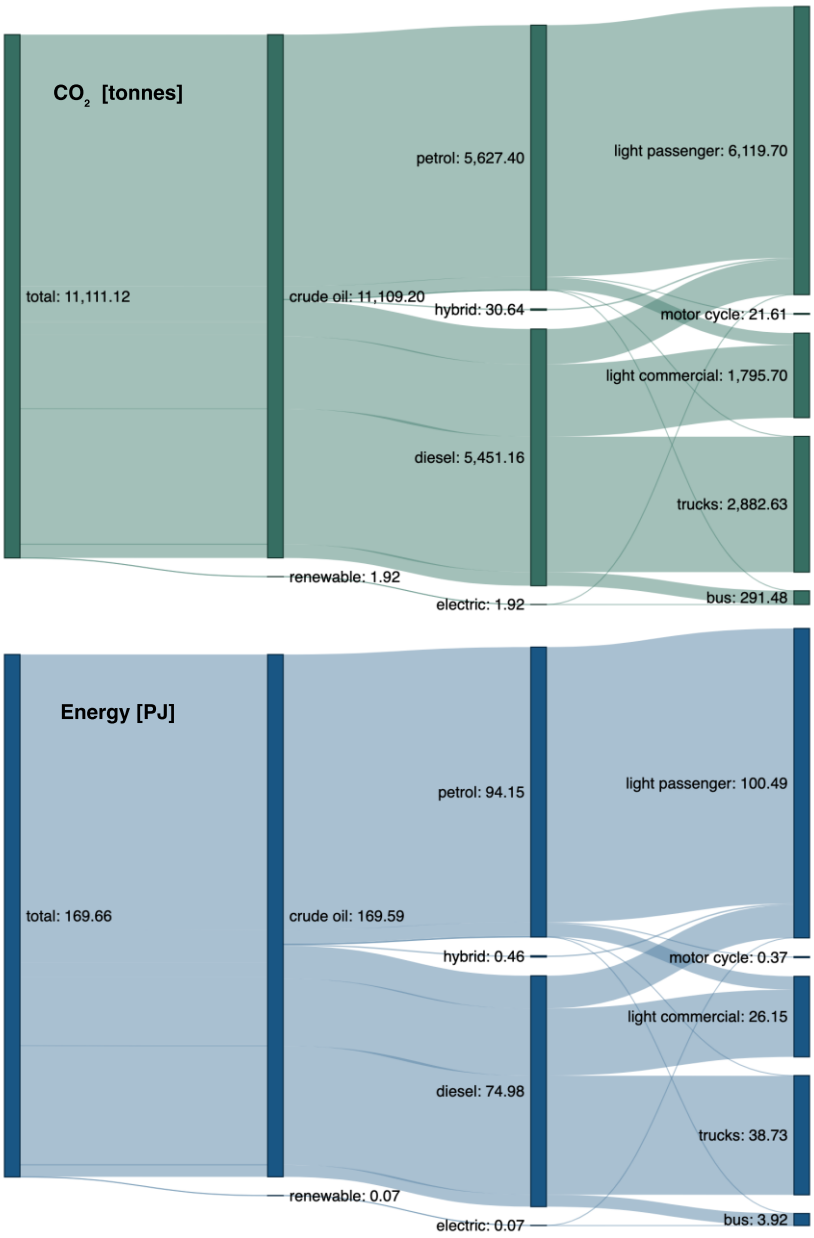

Figure 1. (Top) CO_2, in tonnes, emitted and (Bottom) energy, in PJ, consumed by the New Zealand vehicle fleet in the year 2018

Two low-emission future scenarios

In this section, two possible future scenarios are sketched. One scenario where a large amount of battery-powered electric vehicles (BEVs) are introduced and a second scenario where also fuel cell electric vehicle (FCEV) make up a significant portion of the amount of New Zealand vehicles. The goal of this analysis is to determine the potential of lowering the CO_2 emission by introducing more BEV and FCEV in New Zealand and secondly to determine the resulting demand of renewable energy generators.

Scenario 1: 60% of all diesel and petrol vehicles become battery electric

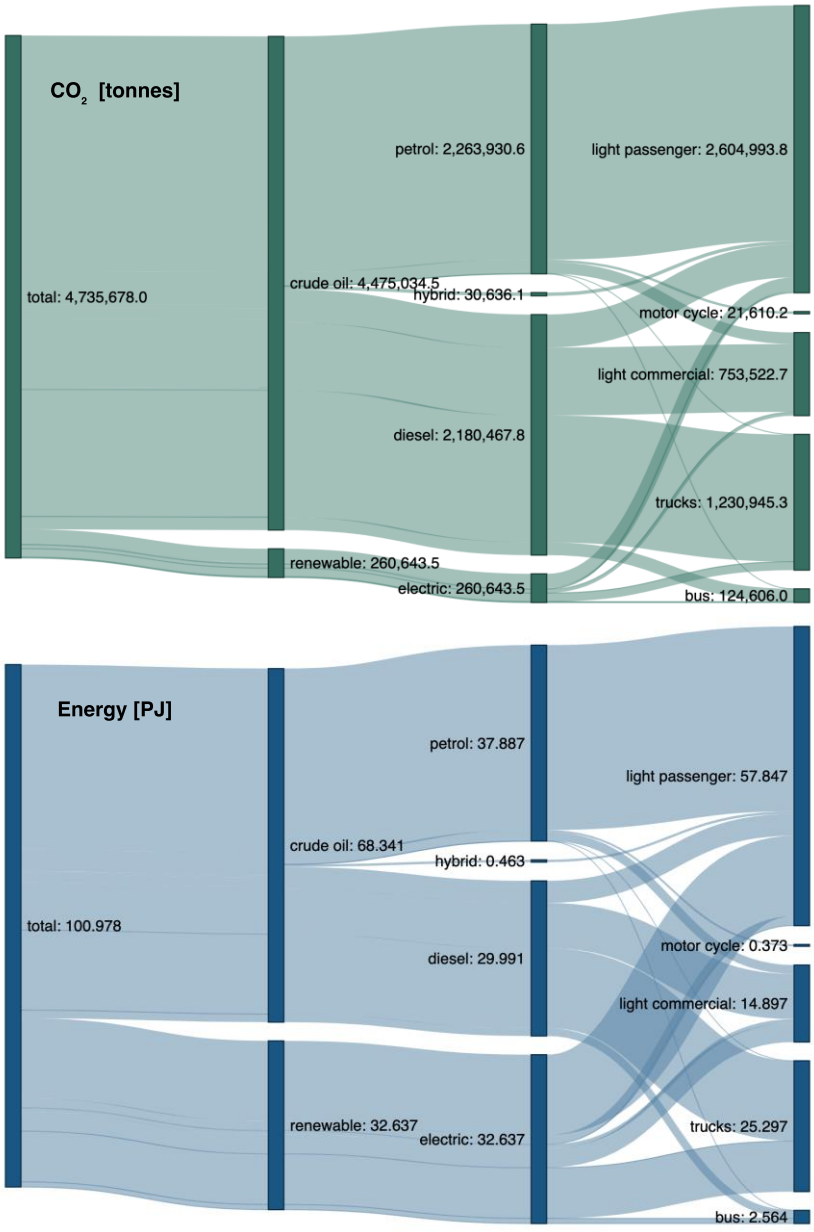

Figure 2. (Top) CO_2, emitted (in tonnes) and (Bottom) energy, consumed by the New Zealand vehicle fleet according to scenario 1, where is assumed that 60 % of all diesel and petrol vehicles become battery electric (in PJ).

Scenario 2: 30% of the diesel and petrol vehicles to become electric and 20% run on hydrogen

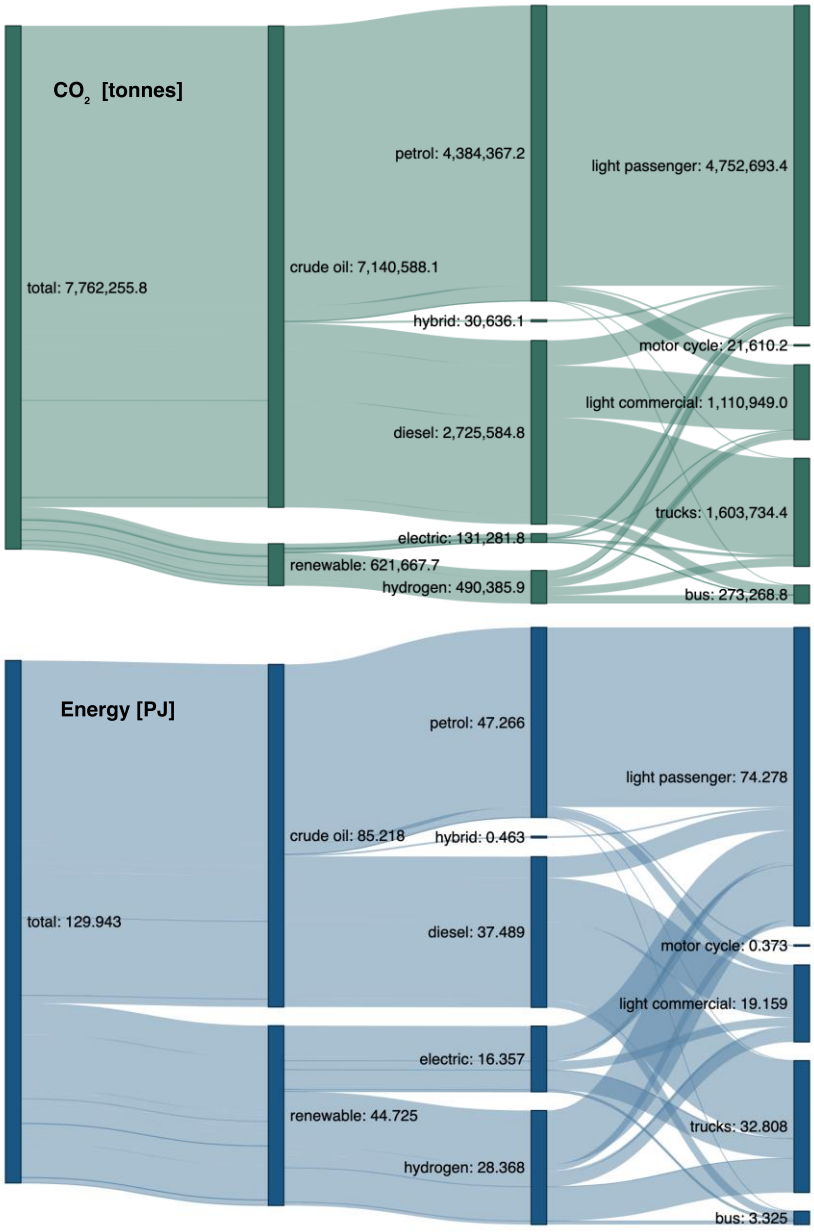

Figure 3. (Top) CO_2 , emitted (in tonnes) and (Bottom) energy, consumed by the New Zealand vehicle fleet according to scenario 2, where is assumed that 30% of the diesel and petrol vehicles become electric and 20% run on hydrogen (in PJ).

Comparison of scenario 1 & 2

- In scenario 1 (40% internal combustion engines [ICE], 60% BEV), the carbon emission decreases by 58%, from 11.1 million tonnes CO_2 to 4.7 million tonnes CO_2. Thirty-three PJ of electricity would need to be generated with an average carbon intensity of 28 gCO_2/kWh.

- In scenario 2 (50% ICE, 30% BEV, 20% FCEV), the carbon emission decreases by 45%to 6.1 million tonnes CO_2. Forty-five PJ of electricity would need to be generated with an average carbon intensity of 28 gCO_2/kWh.

- However, the question arises if it would be achievable to supply enough low-emission energy for one of these two scenarios to become a reality and what the timeframe for such a scenario would be. According to scenario 1, the new electricity that would need to be generated would equate to something of the order of 192 km² of new windfarm parks and new 50 km² of solar parks needing to be built in New Zealand.

Appendices

Tables for emissions and energy use scenarios

Appendix 1: Table for vehicle emissions and energy use 2018

		distance	quantity	distance per vehicle	carbon intensity	total carbon intensity	total carbon intensity	fuel consumption	energy consumption	total fuel	total energy	total energy
		million kilometres	Year 2018	km/vehicle/year	Average gCO_2/km	$kgCO_2$/vehicle/year	tonnes CO_2 total	L/km	kWh/km	million litres	GWh	PJ
light passenger	petrol	31979	3157190	10129	167	1691	5338920	0.08		2558.35	24815.96	89.34
	diesel	3690	297079	12421	203	2519	748455	0.08		295.21	2952.12	10.63
	electric	77	8816	8762	22	191	1688		0.23		17.38	0.06
	hybrid	295	33619	8762	104	911	30636	0.05		13.26	128.58	0.46
	total	**36041**	**3496704**	**10307**			**6119699**				**27914.05**	**100.49**
light commercial	petrol	1548	161011	9612	167	1605	258374	0.08		123.81	1200.95	4.32
	diesel	7580	486288	15587	203	1722	1537332	0.08		606.37	6063.68	21.83
	total	**9127**	**647299**	**14100**			**1795706**				**7264.64**	**26.15**
motor cycle	**total (petrol)**	**414**	**179761**	**2304**	52	120	**21610**	0.03		10.36	**103.55**	**0.37**
trucks	petrol	9	3023	3030	837	2535	7662	0.35		3.21	31.10	0.11
	diesel	3065	150373	20383	938	19119	2874970	0.35		1072.75	10727.50	38.62
	total	**3074**	**153396**	**20041**			**2882632**				**10758.60**	**38.73**
bus	petrol	1	192	5261	837	4401	845	0.35		0.35	3.43	0.01
	diesel	310	11215	27607	938	25895	290413	0.35		108.36	1083.63	3.90
	electric	2	92	18017	140	2527	233		1.48		2.45	0.01
	total	**312**	**11499**	**27157**			**291490**				**1089.51**	**3.92**
		total vehicles	**4488659**			**total carbon intensity**	**11111137**			**total energy**	**47130**	**170**

Distance covered per vehicle, quantity of vehicles, total CO_2 emission, fuel consumption and total energy consumed by fleet type. Year 2018.

Appendix 2: Table for transport emissions and energy use in Scenario 1

scenario 1		distance	quantity	distance per vehicle	carbon intensity	total carbon intensity	total carbon intensity	fuel consumption	energy consumption	total fuel	total energy	total energy
		million kilometres	Year 2018	km/vehicle/year	Average gCO_2/km	$kgCO_2$/vehicle/year	tonnes CO_2 total	L/km	kWh/km	million litres	GWh	PJ
light passenger	petrol	12792	1262876	10129.0	167	1691.0	2135568.0	0.08		1023.338535	9926	35.73
	petrol to electric	19188	1894314	10129.0	6	65.2	123472.2		0.225		4317	15.54
	diesel	1476	118831.6	4968.6	203	1007.8	299381.9	0.08		118.084924	1181	4.25
	diesel to electric	2214	178247.4	4968.6	6	32.0	14247.7		0.225		498	1.79
	electric	77.2	8816.0	8762.3	22	191.5	1687.9		0.225		17	0.06
	hybrid	294.6	33619.0	8762.3	104	911.3	30636.1	0.045		13.25602248	129	0.46
	total	**36041.3**	**3496704.0**	**10307.2**			**2604993.8**				**16069**	**57.85**
light commercial	petrol	619	64404.4	9611.9	167	1604.7	103349.6	0.08		49.52387235	480	1.73
	petrol to electric	929	96606.6	9611.9	6	61.9	5975.4		0.225		209	0.75
	diesel	3032	194515.2	15586.7	203	1721.9	614932.8	0.08		242.5473514	2425	8.73
	diesel to electric	4548	291772.8	15586.7	6	100.3	29264.9		0.225		1023	3.68
	total	**9127**	**647299**	**14100.5**			**753522.6**				**4138**	**14.90**
motor cycle	**total (petrol)**	**414**	**179761**	**2304.2**	52	120.2	**21610.2**	0.025		10.3553425	**104**	**0.37**
trucks	petrol	4	1209.2	3029.9	837	2534.5	3064.8	0.35		1.282327563	12	0.04
	petrol to electric	5	1813.8	3029.9	42	128.0	232.1		1.48		8	0.03
	diesel	1226	60149.2	20382.6	938	19118.9	1149988.0	0.35		429.1	4291	15.45
	diesel to electric	1839	90223.8	20382.6	42	860.8	77660.4		1.48		2715	9.78
	total	**3074**	**153396**	**20040.7**			**1230945.2**				**7027**	**25.30**
bus	petrol	0.404049803	76.8	5261.1	837	4400.9	338.0	0.35		0.141417431	1	0.00
	petrol to electric	0.606074705	115.2	5261.1	42	222.2	25.6		1.48		1	0.00
	diesel	123.8434306	4486	27606.6	938	25895.0	116165.1	0.35		43.34520071	433	1.56
	diesel to electric	185.7651459	6729	27606.6	42	1165.8	7844.8		1.48		274	0.99
	electric	1.657548082	92	18016.8	140	2527.3	232.5		1.48		2	0.01
	total	**312.2762491**	**11499**	**27156.8**			**124606.0**				**712**	**2.56**
		total vehicles	**4488659**			**total carbon intensity**	**4735678**			**total energy**	**28050**	**101**

Distance covered per vehicle, quantity of vehicles, total CO_2 emission, fuel consumption and total energy consumed by fleet type. Scenario 1 assumed that 60% of all diesel and petrol vehicles (with exception of the motor vehicles) become electric.

Appendix 3: Table for transport emissions and energy use in Scenario 2

scenario 2		distance	quantity	distance per vehicle	carbon intensity	total carbon intensity	total carbon intensity	fuel consumption	energy consumption	total fuel	total energy	total energy
		million kilometres	Year 2018	km/vehicle/year	Average gCO_2/km	$kgCO_2$/vehicle/year	tonnes CO_2 total	L/km	kWh/km	million litres	GWh	PJ
light passenger	petrol	15990	1578595	10129.0	167	1691.0	2669460.0	0.08		1279.17	12408	44.67
	petrol to electric	9594	947157	10129.0	6	65.2	61736.1		0.23		2159	7.77
	petrol to hydrogen	6396	631438	10129.0	17	170.3	107558.0		0.59		3761	13.54
	diesel	1845	148539.5	4968.6	203	1007.8	374227.4	0.08		147.61	1476	5.31
	diesel to electric	1107	89123.7	4968.6	6	32.0	7123.8		0.23		249	0.90
	petrol to hydrogen	738	59415.8	4968.6	17	83.6	12411.3		0.59		434	1.56
	electric	77.2	8816.0	8762.3	22	191.5	1687.9		0.23		17	0.06
	hybrid	294.6	33619.0	8762.3	104	911.3	30636.1	0.045		13.26	129	0.46
	total	**36041.3**	**3496704.0**	**10307.2**			**3264840.6**				**20632**	**74.28**
light commercial	petrol	774	80505.5	9611.9	167	1604.7	129187.0	0.08		61.90	600	2.16
	petrol to electric	464	48303.3	9611.9	6	61.9	2987.7		0.23		104	0.38
	petrol to hydrogen	310	32202.2	9611.9	17	65.2	61736.1		0.59		182	0.66
	diesel	3790	243144	15586.7	203	1721.9	768666.0	0.08		303.18	3032	10.91
	diesel to electric	2274	145886.4	15586.7	6	100.3	14632.4		0.23		512	1.84
	diesel to hydrogen	1516	97257.6	15586.7	17	65.2	61736.1		0.59		891	3.21
	total	**7611**	**647299**	**11758.6**			**1038945.2**				**5322**	**19.16**
motor cycle	**total (petrol)**	**414**	**179761**	**2304.2**	52	120.2	**21610.2**	0.025		10.36	**104**	**0.37**
trucks	petrol	5	1511.5	3029.9	837	2534.5	3831.0	0.35		1.60	16	0.06
	petrol to electric	3	906.9	3029.9	42	128.0	116.0		1.48		4	0.01
	petrol to hydrogen	2	604.6	3029.9	110	65.2	61736.1		3.86		7	0.03
	diesel	1532.5	75186.5	20382.6	938	19118.9	1437485.0	0.35		536.38	5364	19.31
	diesel to electric	919.5	45111.9	20382.6	42	860.8	38830.2		1.48		1358	4.89
	diesel to hydrogen	613	30074.6	20382.6	110	65.2	61736.1		3.86		2365	8.52
	total	**2461**	**153396**	**16044.5**			**1603734.4**				**9114**	**32.81**
bus	petrol	0.505062254	96	5261.1	837	4400.9	422.5	0.35		0.18	2	0.01
	petrol to electric	0.303037352	57.6	5261.1	42	222.2	12.8		1.48		0.45	0.002
	petrol to hydrogen	0.202024902	38.4	5261.1	110	65.2	61736.1		3.86		1	0.003
	diesel	154.8042883	5607.5	27606.6	938	25895.0	145206.4	0.35		54.18	542	1.95
	diesel to electric	92.88257296	3364.5	27606.6	42	1165.8	3922.4		1.48		137	0.49
	diesel to hydrogen	61.92171531	2243	27606.6	110	65.2	61736.1		3.86		239	0.86
	electric	1.657548082	92	18016.8	140	2527.3	232.5		1.48		2	0.01
	total	**312.2762491**	**11499**	**27156.8**			**273268.8**				**923**	**3.32**
		total vehicles	**4488659**			**total carbon intensity**	**6202399**			**total energy**	**36095**	**130**

Distance covered per vehicle, quantity of vehicles, total CO_2 emission, fuel consumption and total energy consumed by fleet type. Scenario 2 assumed that 30% of the diesel and petrol vehicles become electric and 20% will run on hydrogen.

Appendix 4: Energy output and carbon intensity for the year 2018, for a scenario where 60% of the ICE are substituted with BEVs (scenario 1), and for a scenario where 30% are substituted with BEVs and 20% with FCEVs (scenario 2)

ICE/BEV/FCEV	2018	scenario 1 0.4/0.6/0.0	scenario 2 0.5/0.3/0.2
	carbon intensity tonnes CO_2	carbon intensity tonnes CO_2	carbon intensity tonnes CO_2
low emission	1920	260643	621668
petrol/diesel/hybrid	11109217	4475034	5580732
total	11111137	4735678	6202399
	Energy PJ	Energy, PJ	Energy, PJ
low emission	0.1	33	45
petrol/diesel/hybrid	170	68	85
total	170	101	130