The problem with Methane

Les Jones 18th July 2018,

In the consultation on the zero carbon bill, the government asks for views on which net-zero target is the right one for NZ and gives three options:

a) "**Net zero carbon dioxide by 2050 (but not other gases like methane…).**" This option is wrong because the warming effect of methane is so great that it needs to be reduced rapidly (not ignored) if NZ is to play its part in the global reduction effort.

b) **"Net zero long-lived gases and stabilised short-lived gases by 2050."** There are two problems with this option

Firstly, any more lenient future reduction effort with methane compared to CO2, is, deviously, counting methane's "short-lived" factor twice. To explain: when the annual amount of methane emitted is stated in our ghg Inventory, it is given in Mtns of CO2equivalaent. This means that its short-livedness is already accounted for by using its GWP100 value of 28 times the warming of CO2. This enables us to say that methane makes up 43% of our ghg emissions while CO2 makes up 44%. Now, if we adopt option b), and we say again that because methane is a short lived gas we are only going to stabilise it, but reduce CO2 to net zero, then we are double counting methane's short-livedness. Surely if its shortlivedness has been counted in the inventory already, then both CO2 and methane, (both measured in CO2e) must be treated equally, i.e. both reduced the same!

Secondly, it is not stated at what level short-lived gases (methane) are to be stabilised. If they are currently at an unsustainable level, they need to be reduced, not stabilised. Central to deciding at what level to stabilise, is the issue of how methane is measured against CO2. I maintain that both GWP 100 and GWP 20 (measuring methane's warming effect over a 100-year time frame, 28x Co2, and over a 20-year timeframe, 86xCO2) seriously underestimate the warming effect of methane compared to CO2. I have concluded (and discuss below) that the 1.2 Mtns of methane which New Zealand emits annually is more damaging to the atmosphere than our 34 Mtns of CO2 gross and several times more damaging than our net CO2 emissions of 11.76Mtn CO2. Methane emissions need to be seriously reduced, not "stabilised." In fact, a greater effort needs to be put into reducing methane than into reducing CO2. This is the reverse of what you are proposing in option b)

c) "**Net zero emissions by 2050: this target would reduce net emissions across all greenhouse gases to zero by 2050."** This assumes that because methane can't be sequestered by forests it would have to be offset by negative CO2 emissions, so that when our CO2, N20 and CH4 emissions and the forest sink are all added together, the outcome is net zero greenhouse gas emissions. This option suffers from the same weakness as b), i.e. how do you equate 1.2 Mtns of methane against 34Mtns of CO2 and net them off. Once again, I believe that the GWP method seriously undercounts methane.

Conclusion: I support c) but suggest that CO2 levels would have to be hugely negative in order to offset the enormous warming effect of methane and methane would have to be enormously reduced to make this realistic, i.e. be stabilised at much closer to zero. I do understand that this would mean we would have to lower the number of cows, sheep and deer in the country. If that is what is required to save the human species from extinction, then that is what we have to do.

The following analysis sets out to establish the warming effect of our current methane emissions and to model a reduction scenario and its effect on our atmospheric warming.

The Analysis

The crucial factor about greenhouse gases is how much they warm the planet. Now methane is a much more powerful warming agent than CO2 although it breaks down over 10 years or so but there is still 5% of it left after 50 years. While it is obvious that CO2 accumulates in the atmosphere because it lasts for centuries, the accumulation of methane is much harder to visualize. Basically the 1.2 Mtns of methane NZ produces each year is added to previous years' emissions which are in the process of breaking down. So, unless the annual amount of methane emitted reduces, which it hasn't in NZ over the last 26 years, methane is still slowly accumulating in our atmosphere. What NZ needs to do and what I have modelled, is calculate what sort of reduction in the annual output of methane would be required for methane levels to a) stop rising, and b) reduce over time to a level where NZ could say that it was honestly playing its part in the global effort to prevent more than 2 degrees of warming. Our government defines this effort as reaching net-zero emissions by 2050 which to my mind has no scientific basis, but that is another story. My contention is that the public does not realise that getting to net zero when we include methane is impossible without radical changes to our economy; planting a billion trees or switching transport to electric vehicles will not get us there.

Measuring Methane

As mentioned in option b) and c) above, how we measure Methane compared to CO2 is critical and there are three ways of doing this

1.Measuring its effect over 100 years which is the international standard. Under this measure it is a 28 times more potent greenhouse gas than CO2. So, for NZ the 43% of our emissions that methane causes, is achieved by 1.2 million tonnes of methane, while the 44% of our emissions caused by CO2 requires 34 million tonnes of CO2. My problem with this measure is that for most countries it doesn't matter too much because only 15% of their emissions are methane. However, for NZ, methane makes up 43% of our emissions and our economy is hugely reliant on the products which cause these emissions. Another problem is that we don't have 100 years in which to save the planet from disaster. It is a convenient evasion to count the effects of methane over 100 years when our target for net-zero emissions is only 32 years away! This measure seriously underrates the serious warming effects of methane.

2.Measuring its effect over 32 years. While this is more honest, it rates methane as 77 times more powerful than CO2, but it still underrates the warming effect of methane. We are having to deal with methane from next year onwards, therefore I contend that we need to look at the immediate effect of the methane that we are emitting this year and next.

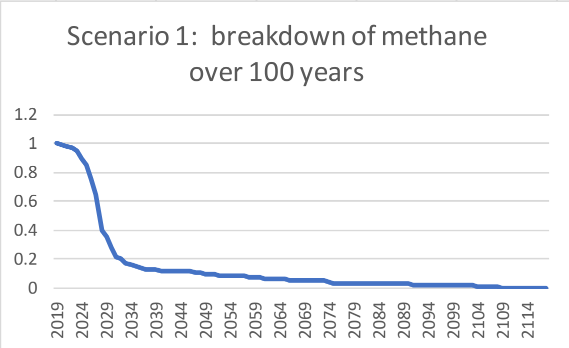
3.A third way of assessing methane's warming is to track its effect on a year by year basis. To do this I have started at 1990, the first year for which the NZ inventory gives reliable figures. The results of these historical emissions are shown in Table 2. Several assumptions are made

- New Zealand's annual methane emissions have hardly risen since 1990, but have varied within a narrow band from 1.15 Mtns in 1993 to 1.27 Mtns in 2005. I have averaged this at 1.22Mtn which is precisely the level it was at in 2015.
- I have constructed a breakdown curve for methane, Table 1, based on two statements. Firstly, that methane breaks down over 9-12 years and secondly Dr David Frame's observation that 5% of methane remains after 50 years. Thirdly, I have calculated the GWP 100 and GWP 20 for my curve at 17 and 62.2 respectively. Therefore, I am confident that although it is not based on exact scientific data, it is a good approximation and, more

importantly, a conservative one. In other words, my graph also comfortably underestimates the warming effect of methane and its dire conclusions are therefore an understatement.

Table 1 How methane breaks down over 100 years

	new methane curve				
				GWP 20	62.2
	new curve	nz methane		GWP 32	44
		x120	accum	GWP100	17.6
2019	1	120			
2020	0.99	118.8			
2021	0.98	117.6			
2022	0.97	116.4			
2023	0.95	114			
2024	0.9	108			
2025	0.85	102			
2026	0.75	90			
2027	0.65	78			
2028	0.4	48			
2029	0.35	42			
2030	0.28	33.6			
2031	0.22	26.4			
2032	0.2	24			
2033	0.17	20.4			
2034	0.16	19.2			
2035	0.15	18			
2036	0.14	16.8			
2037	0.13	15.6			
2038	0.127	15.24	1244	62.2	GWP20
2039	0.125	15			
2040	0.12	14.4			



Explanation of Table 1.

Column 1 is the table for the graph on the right

Column 2 is the equivalent units of CO2 required to achieve the same atmospheric warming. Taking the effect of one unit of methane as being 120 times greater than a unit of CO2 in the year that it is emitted.

Column 3 is the accumulated methane which, divided by 20, gives the averaged effect of the methane over 20 years. Note that these GWPs are well below those given by the EPA and used in the NZ greenhouse gas inventory

Note that years 22 to 100 have been omitted from this essay to save space, but they have been used to calculate GWP 32 and GWP100.

Table 2A and 2B. New Zealand's historical methane emissions and their breakdown pathway

Explanation for table 2A

Column 1 shows the breakdown trajectory from table 1 above. Note these figures are not included in the annual totals, which begin from column 2 They merely illustrate the breakdown curve from which all other values are calculated

Table 2A. Methane breakdown 1990-2002

	methane	x 1.22												
	breakdow	methane												
	curve	av1990-2050												
1990	1	1.22												
1991	0.99	1.21	1.22											
1992	0.98	1.20	1.21	1.22										
1993	0.97	1.18	1.20	1.21	1.22									
1994	0.95	1.16	1.18	1.20	1.21	1.22								
1995	0.90	1.10	1.16	1.18	1.20	1.21	1.22							
1996	0.85	1.04	1.10	1.16	1.18	1.20	1.21	1.22						
1997	0.75	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22					
1998	0.65	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22				
1999	0.40	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22			
2000	0.35	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22		
2001	0.28	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22	
2002	0.22	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22
2003	0.20	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21
2004	0.17	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20
2005	0.16	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18
2006	0.15	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16
2007	0.14	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10
2008	0.13	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04
2009	0.13	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92
2010	0.13	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79
2011	0.12	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43	0.49
2012	0.12	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34	0.43
2013	0.12	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27	0.34
2014	0.12	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24	0.27
2015	0.12	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21	0.24
2016	0.12	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20	0.21
2017	0.12	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18	0.20
2018	0.11	0.13	0.14	0.14	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.18

Column 2 shows how NZ's 1.22 Mtn of methane emitted in 1990 breaks down over 28 years to 2018. This identical trajectory is also applied to every subsequent annual emission of 1.22 Mtns

Each row from 1990 down shows the sum of emissions for that year. These obviously include the emission from that year plus the partially broken-down emissions still in the atmosphere from previous years.

Table 2B. Methane breakdown 2003 to 2018

																accum	accum		
																methane	methane	co2	CO2
																Mtn	at 120x		cumu
																1.22	146.4	25.45	25.45
																2.43	291.34	26.12	51.57
																3.62	434.81	28.11	79.68
																4.81	576.82	27.71	107.39
																5.97	715.90	27.89	135.28
																7.06	847.66	28.15	163.43
																8.10	972.10	29.38	192.81
																9.02	1081.90	31.36	224.16
																9.81	1177.06	29.93	254.10
																10.30	1235.62	31.53	285.62
																10.72	1286.86	32.36	317.98
																11.07	1327.85	34.58	352.57
																11.33	1360.06	34.77	387.33
1.22																11.58	1389.34	36.49	423.83
1.21	1.22															11.79	1414.22	36.06	459.89
1.20	1.21	1.22														11.98	1437.65	37.65	497.54
1.18	1.20	1.21	1.22													12.16	1459.61	37.52	535.06
1.16	1.18	1.20	1.21	1.22												12.33	1480.10	36.64	571.70
1.10	1.16	1.18	1.20	1.21	1.22											12.49	1499.14	37.66	609.36
1.04	1.10	1.16	1.18	1.20	1.21	1.22										12.65	1517.73	34.81	644.16
0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22									12.80	1536.03	35.01	679.18
0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22								12.95	1553.60	34.33	713.50
0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22							13.09	1571.16	35.97	749.47
0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22						13.24	1588.73	35.21	784.69
0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22					13.39	1606.30	35.61	820.30
0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22				13.53	1623.87	35.84	856.14
0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22			13.67	1640.70	34.46	890.60
0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22		13.81	1657.54	34.46	925.06
0.20	0.21	0.24	0.27	0.34	0.43	0.49	0.79	0.92	1.04	1.10	1.16	1.18	1.20	1.21	1.22	13.95	1673.64	34.46	959.52

Explanation of table 2B

This table continues tracking methane emissions from 2003 until 2018, the present day. The latest available stats are from the 2016 inventory, therefore, in light of the small variation from the 1990 to 2016 period, it is assumed that annual emissions will remain at 2016 levels for 2017 and 2018.

On the right hand side are the annual totals for all the years 1990 to 2018 (i.e.from both table2A and 2B). The first column shows that with annual emissions stable at 1.22, methane increasingly accumulates in the atmosphere. By 2018 its warming effect shown in column 2, measured in CO2 equivalents is 1763 million tonnes whereas the warming effect of the accumulated gross CO2 since 1990, shown in column 4 is only 959 Mtns, a bit over half that of methane

Column 3 lists NZ annual CO2 emissions 1990 to 2016, then assumes level emissions for 2017 and 2018.

Column 4 shows accumulated CO2 emissions 1990 to 2018. Note that the total by 2018 of 959 Mtns is only 57% of the annual emissions of methane. The conclusion from this is that NZ has a much bigger job reducing methane than CO2, especially since methane can not be sequestered by trees.

The next step is to project methane emissions forward to 2050. For this we assume a reduction of 3% year from 2019. In other words each year’s methane emissions are 3% less than the previous year. There are two aspects to note: A) The reduction will be in a curve, meaning that it starts off steeper then flattens out. B) The level of methane (unlike CO2) can never drop below zero

Table 3. Annual methane emissions assuming a 3% year on year reduction from 2019. Note that the complete spreadsheet forTable 3 can be found at www.climatefirstnz.org

Table 3A 2018-2037

Methane trajectory 2018-2037																				
2018	1.22																			
2019	1.21	1.18																		
2020	1.20	1.17	1.15																	
2021	1.18	1.16	1.14	1.11																
2022	1.16	1.15	1.13	1.10	1.08															
2023	1.10	1.12	1.12	1.09	1.07	1.05														
2024	1.04	1.07	1.09	1.08	1.06	1.04	1.02													
2025	0.92	1.01	1.04	1.05	1.05	1.03	1.01	0.99												
2026	0.79	0.89	0.98	1.00	1.03	1.02	1.00	0.98	0.96											
2027	0.49	0.77	0.86	0.94	0.97	1.00	0.99	0.97	0.95	0.93										
2028	0.43	0.47	0.75	0.83	0.92	0.95	0.97	0.96	0.94	0.92	0.90									
2029	0.34	0.41	0.46	0.72	0.81	0.89	0.92	0.94	0.93	0.91	0.89	0.87								
2030	0.27	0.33	0.40	0.44	0.70	0.79	0.87	0.89	0.91	0.90	0.88	0.86	0.85							
2031	0.24	0.26	0.32	0.39	0.43	0.68	0.77	0.84	0.86	0.88	0.87	0.85	0.84	0.82						
2032	0.21	0.24	0.25	0.31	0.38	0.42	0.66	0.74	0.82	0.84	0.86	0.84	0.83	0.81	0.80					
2033	0.20	0.20	0.23	0.24	0.30	0.37	0.41	0.64	0.72	0.79	0.81	0.83	0.82	0.80	0.79	0.77				
2034	0.18	0.19	0.20	0.22	0.24	0.29	0.36	0.40	0.62	0.70	0.77	0.78	0.81	0.80	0.78	0.76	0.75			
2035	0.17	0.18	0.18	0.19	0.22	0.23	0.29	0.35	0.38	0.60	0.68	0.74	0.77	0.78	0.78	0.75	0.74	0.73		
2036	0.16	0.17	0.17	0.18	0.18	0.21	0.22	0.28	0.34	0.37	0.59	0.65	0.72	0.74	0.76	0.75	0.74	0.72	0.71	
2037	0.15	0.15	0.16	0.17	0.17	0.18	0.20	0.22	0.27	0.33	0.36	0.57	0.64	0.70	0.72	0.73	0.73	0.72	0.70	

Explanation of table 3A

Column 1 shows the 2018 methane emissions and how they break down through to 2037, assuming a 3% reduction beginning in 2019. Each column thus represents each year's methane and what happens to it over the next 19 years.

On the other hand, reading across each year row gives the total amount of methane present in the atmosphere and doing its warming in any one year. For example, in 2020 (the third row down) 1.15 Mtns of methane is put into the air to join the 1.17 Mtns left in the atmosphere from last year. It is also added to the 1.2 Mtns left from 2018. Therefore, in total there will be 3.47 Mtns of methane in the air warming the atmosphere in 2020.

Note that the figure at the top of each column is the initial methane emissions from each year, and thus is reducing at 3% year on year.

Table 3B, accumulated methane from 2038 to 2050.   And totals from 1990 to 2050

																net CO2	
														Methane	x 120	red 3%	net CO2
														Mtns	Mtn CO2e	from 2019	cumu
														1.22	146.40	-4.55	-4.55
														2.43	291.34	-5.98	-10.53
														3.62	434.81	-3.59	-14.12
														4.81	576.82	-4.59	-18.71
														5.97	715.90	-4.41	-23.12
														7.06	847.66	-2.65	-25.77
														8.10	972.10	-1.12	-26.89
														9.02	1081.90	-0.04	-26.93
														9.81	1177.06	-1.87	-28.8
														10.30	1235.62	-1.87	-30.67
														10.72	1286.86	0.06	-30.61
														11.07	1327.85	2.88	-27.73
														11.33	1360.06	5.47	-22.26
														11.58	1389.34	6.09	-16.17
														11.79	1414.22	5.66	-10.51
														11.98	1437.65	8.85	-1.66
														12.16	1459.61	10.42	8.76
														12.33	1480.10	11.64	20.4
														12.49	1499.14	4.06	24.46
														12.65	1517.73	4.51	28.97
														12.80	1536.03	4.51	33.48
														12.95	1553.60	8.23	41.71
														13.09	1571.16	10.47	52.18
														13.24	1588.73	11.01	63.19
														13.39	1606.30	11.91	75.1
														13.53	1623.87	12.14	87.24
														13.67	1640.70	11.76	99
														13.81	1657.54	11.76	110.76
														13.95	1673.64	11.76	122.52
														14.04	1685.36	11.3925	133.9125
														14.09	1691.39	11.025	144.9375
														14.11	1693.62	10.6575	155.595
														14.09	1691.32	10.29	165.885
														14.04	1684.28	9.9225	175.8075
														13.95	1674.17	9.555	185.3625
														13.84	1661.20	9.1875	194.55
														13.70	1644.34	8.82	203.37
														13.55	1625.43	8.4525	211.8225
														13.38	1605.53	8.085	219.9075
														13.19	1583.28	7.7175	227.625
														13.00	1560.49	7.35	234.975
														12.82	1538.88	6.9825	241.9575
														12.62	1514.18	6.615	248.5725
														12.42	1490.79	6.2475	254.82
														12.22	1466.92	5.88	260.7
														12.03	1443.76	5.5125	266.2125
														11.84	1421.29	5.145	271.3575
														11.65	1397.98	4.7775	276.135
2038	0.66													11.45	1374.07	4.41	280.545
2039	0.65	0.64												11.25	1350.48	4.0425	284.5875
2040	0.65	0.63	0.62											11.06	1327.39	3.675	288.2625
2041	0.64	0.63	0.61	0.61										10.87	1304.47	3.3075	291.57
2042	0.63	0.62	0.61	0.60	0.59									10.69	1283.10	2.94	294.51
2043	0.59	0.61	0.60	0.60	0.58	0.57								10.51	1261.78	2.5725	297.0825
2044	0.56	0.58	0.59	0.59	0.58	0.56	0.55							10.34	1240.51	2.205	299.2875
2045	0.50	0.54	0.56	0.58	0.57	0.56	0.54	0.54						10.15	1217.82	1.8375	301.125
2046	0.43	0.48	0.53	0.55	0.56	0.55	0.54	0.53	0.52					9.96	1194.96	1.47	302.595
2047	0.26	0.42	0.47	0.52	0.53	0.54	0.53	0.53	0.51	0.50				9.77	1171.98	1.1025	303.6975
2048	0.23	0.26	0.40	0.46	0.50	0.51	0.52	0.52	0.51	0.50	0.49			9.57	1148.79	0.735	304.4325
2049	0.18	0.22	0.25	0.40	0.44	0.48	0.50	0.51	0.50	0.49	0.49	0.47		9.39	1126.60	0.3675	304.8
2050	0.15	0.18	0.22	0.24	0.38	0.43	0.47	0.49	0.49	0.49	0.48	0.47	0.46	9.20	1103.93	0	304.8

Explanation of Table 3B

This table tracks what happens to NZ's methane from 2038 to 2050 and on the right side gives the totals for all years 1990 to 2050 as derived from Tables 2, 3A and 3B.

The first column shows the Mtns of methane emitted in each year. Notice most importantly, that emissions peak in 2021 and begin to reduce until by 2050 they are back to 1997 levels.

Column two shows the actual warming effect of each year's column one emissions by multiplying by 120, the amount that methane warms relative to CO2 in the year it is emitted.

Column three shows NZ's net CO2 emissions from 1990 to 2016. This is calculated by subtracting the forest sink from the gross CO2 emissions. Level emissions are assumed from 2017 and 2018 and a straight-line reduction to zero in 2050 Remarkably, NZ had negative net CO2 emissions for many years. What is also remarkable is the drop in net CO2 emissions from 2007 to 2008 of 64% because of the Global Financial Crisis. This demonstrates the strong link between increasing CO2 and economic growth. The huge fall in CO2 was caused by a simultaneous drop in both forest harvesting and industrial activity.

Column four is the accumulated CO2 emissions from column three. Notable here is that because of our negative emissions from 1990 to 1999, our cumulative CO2 emissions remained negative until 2005. As well, even by 2050, our accumulated emissions were only 304 Mtns. This is less than one third of the warming effect of our methane emissions in that year!! It is also far less than our permitted CO2 budget based on NZ's population as a percentage of the world's population of 660 Mtns.

The conclusion from this model are:

1. That New Zealand could easily reduce its CO2 emissions to zero by 2050, and even have negative CO2 emissions as in the 1990 to 1999 period.
2. That our major task is reducing methane emissions, not CO2.
3. Reducing methane is much harder because it can not be sequestered by forests, but only by a reduction in methane emissions themselves.
4. A reduction of more than 3% year on year will be needed, because, although after 2021 methane levels have stabilised and are falling, they are still at a hugely too high level.
5. If option c) becomes NZ's choice there is almost no chance that CO2 levels can become negative enough to offset methane's warming with merely a 3% annual reduction in methane emissions.
6. How a 3% reduction could be done, still needs work. Assuming that all livestock sectors made equal reductions, a 3% reduction in the 4.8 million dairy stock numbers would be 144,000 fewer each year, or 343 fewer average farms each year.

(Note that the above analysis uses real-time methane emissions. A similar analysis using GWP 100 and GWP32 is a work in progress and not finalized in time to meet the submission deadline. I will submit it soon and hope that it will also be considered.)

1.How much methane does NZ emit?

In the 2016 NZ greenhouse gas inventory, methane made up 43% of our emissions

Our total gross emissions were78.7 Mtns **CO_2e**

Therefore, methane emissions were 33.8 Mtns **CO_2e** (43% of 78.7)

[*CO_2e or CO_2 equivalent is a way of comparing different gases. For example CO_2 is called 1, while methane is 28 and Nitrous oxide about 200. These are, by international convention, measured over 100 years. Because methane breaks down over 10 years, its Global Warming Potential is much higher over a shorter period, say 20 years, when its GWP is 86. The GWP100, thus underrates the effect of methane in NZ for which methane makes up a large portion of our emissions compared to all other developed countries]*

Now, to calculate the amount of methane, our 33.8 Million tonnes CO_2e was counted at 28 times warming strength of CO_2 (GWP100)

Therefore, NZ emitted **1.2 Million Tonnes** of methane in 2016. [33.8 divided by 28]

2.What is the warming effect of that 1.2 Mtns of methane?

We know that, in its first year, methane is a 120 times more powerful GW agent than CO_2, which means that one tonne of methane has the same effect as 120 tonnes of CO_2 in its first year, but it rapidly reduces over about 10 years.

I have used two reduction scenarios to track the presence and effect of methane in New Zealand's atmosphere over the next 32 years to 2050 which is our target year. Scenario 1 assumes that methane breaks down entirely to zero in 10 years and that none at all remains for the next 90 years. The second scenario (yet to be developed) has methane breaking down in a curve, reaching about a quarter in 10 years and then 5% remaining after 50 years.

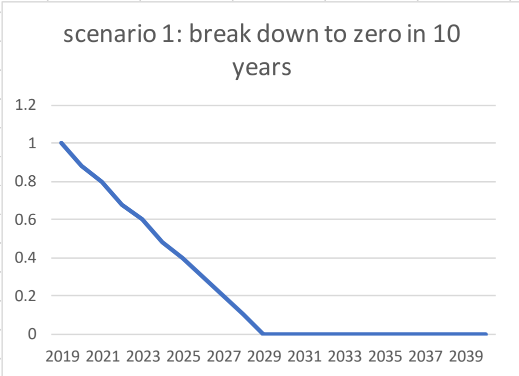
Scenario 1: Tracking 1 Mtn of methane reducing to zero over 10 years, then remaining at zero for the next 90 years.

Note that this trajectory produces a GWP20 of 32.6x and a GWP100 of 6.5x. These are far below the currently used ones, therefore this scenario hugely understates the effect of methane. But even using this absolutely-best-case scenario the accumulating effect is alarming and demonstrates that the commonly-used GWP 100 (which rates NZ methane's effect as equivalent to 33.8 Mtns of CO_2) is miles out.

Let's use scenario 1 to properly track the effect of methane on NZ's emissions

Table 1. The effect of methane in CO_2 equivalents over 10 years

new methane straight line					
		gwp=			Effect of
	1M tn	x 120	accum	GWP	1.2 Mtns
	methane	Mtns	total		methane
2019	1	120			144
2020	0.88	105.6			126.72
2021	0.8	96			115.2
2022	0.68	81.6			97.92
2023	0.6	72			86.4
2024	0.48	57.6			69.12
2025	0.4	48			57.6
2026	0.3	36			43.2
2027	0.2	24			28.8
2028	0.1	12			14.4
2029	0	0			0
2030	0	0			0
2031	0	0			0
2032	0	0			0
2033	0	0			0
2034	0	0			0
2035	0	0			0
2036	0	0			0
2037	0	0			
2038	0	0	652.8	32.64	GWP 20
2039	0			6.528	GWP100
2040	0				



Explanation:

Column 1 shows how one million tonnes of methane breaks down over 10 years as also shown in the graph.

Column 2 shows the heating effect of this one million tones at 120 times the heating effect of CO2

Column 3 shows the accumulated effect over 10 years

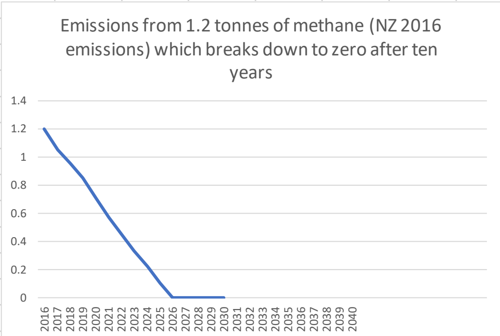
Column 4 is the GWP 20 and 100 which this breakdown scenario results in. Notice how far below the standard ones they are.

Column 5 shows NZ's actual methane emissions for one year (2019). i.e. for 1.2 Mtns, rather than 1 Mtn

Now tracking our emissions over 10 years, assuming a new 1.2 Mtns is emitted every year.

Table 2. NZ methane emissions over 10 years

methane straight line breakdown																annual CH4 MTn	annual CH4 at GWP 120 Mtn CO2e
2016																	
2017																	
2018																	
2019	1.2															1.2	144
2020	1.05	1.2														2.25	270
2021	0.95	1.05	1.2													3.2	384
2022	0.85	0.95	1.05	1.2												4.05	486
2023	0.7	0.85	0.95	1.05	1.2											4.75	570
2024	0.57	0.7	0.85	0.95	1.05	1.2										5.32	638.4
2025	0.45	0.57	0.7	0.85	0.95	1.05	1.2									5.77	692.4
2026	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2								6.1	732
2027	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2							6.32	758.4
2028	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2						6.42	770.4
2029	0	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2					6.42	770.4
2030	0	0	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2				6.42	770.4
2031	0	0	0	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2			6.42	770.4
2032	0	0	0	0	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2		6.42	770.4
2033	0	0	0	0	0	0.1	0.22	0.33	0.45	0.57	0.7	0.85	0.95	1.05	1.2	6.42	770.4
2034																	
2035																	
2036																	
2037																	
2038																	
2039																	
2040																	



Methodology:
Methane emissions have hardly increased since 1990 (5%) compared to 45% for Co2 and 51% for Nitrous oxide.
Therefore for simplicity I have taken the methane emission amount from the 2016 Inventory and assumed that it will be constant over the next 10 years (2019-2028).
This shows:
1. That methane emissions will stabilise in 2028, at 770.4 Mtns CO2e
2. That they will stabilise at an incredibly high level which needs to be urgently reduced

Explanantion:

In year 1 (2019) NZ methane emissions will be 1.2Mtns, which at GWP1 cause 120x the warming of CO2. Therefore, the effect on our atmosphere is the same as 144 Mtns of CO2 i.e. 144Mtns.

In year 2 (2020), another 1.2 Mtns is emitted, but 1.05 Mtns of last year's methane is still there, so there is now 2.25 Mtns of methane warming the atmosphere.

In year 3 (2021), another 1.2 Mtns is emitted, but 1.05 Mtns remains from 2020 plus 0.95 Mtns from 2019. In total there is now 3.2 Mtns of methane in our atmosphere doing its warming.

Now the warming effect of methane is 120 times the warming of CO2 therefore that 3.2 Mtns is causing the equivalent warming of 384 Mtns of CO2. (Right hand column). In other words 11 times as much warming as our 34 Mtns of gross C02 emissions in 2016, and 32 times the warming of our 11.9 Mts of net CO2 emissions in 2016.

This annual accumulation continues until 2028when methane stabilises at 740 Mtns of warming a year.

Conclusion: It is methane that is NZ's worst problem, not CO2, so any attempt to concentrate first on reducing CO2 and worrying about methane later, because it is a "short-lived gas" is completely misguided.

3. How much do we need to reduce methane by so it could be offset by negative CO2 as in option c) of the consultation?

We need a huge reduction, therefore, I explore the effect on our methane emissions of completely eliminating the entire dairy industry and all of its 5 million cows next year! To investigate this, we need to know how much methane dairy emitted. The 2016 ghg inventory gives this as 13.6 Mtns Co2e (using GWP100) Dividing by 28 gives dairy methane at 0.485 Mtns.

So, eliminating the entire dairy herd would reduce our methane emissions from 1.2 Mtns down to 0.715 Mtns. Let's graph that over 10 years

Table 3. Reducing NZ emissions by totally eliminating dairy

NZ methane without dairy																
																Warming
	emissions	emissions													methane	effect
	1 Mtn CH4	0.715 Mtns													Mtns	in CO2e
2019	1	0.715													1.715	205.8
2020	0.88	0.6292	0.715												2.2242	266.904
2021	0.8	0.572	0.6292	0.715											2.7162	325.944
2022	0.68	0.4862	0.572	0.6292	0.715										3.0824	369.888
2023	0.6	0.429	0.4862	0.572	0.6292	0.715									3.4314	411.768
2024	0.48	0.3432	0.429	0.4862	0.572	0.6292	0.715								3.6546	438.552
2025	0.4	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715							3.8606	463.272
2026	0.3	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715						3.9751	477.012
2027	0.2	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715					4.0181	482.172
2028	0.1	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715				3.9896	478.752
2029	0	0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715			3.8896	466.752
2030	0	0	0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715		3.8896	466.752
				0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292	0.715	3.8896	466.752
					0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572	0.6292		
						0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862	0.572		
							0	0.0715	0.143	0.2145	0.286	0.3432	0.429	0.4862		
								0	0.0715	0.143	0.2145	0.286	0.3432	0.429		

The conclusion from this exercise is that removing the entire dairy industry in 2019 would mean that our methane emissions would stabilise at 466 Mtns CO2e from2029 onwards. This is still 13 times more than our 2016 methane emissions using GWP100 as in the GHG Inventory.

Our situation is hopeless. The 2016 inventory states that 35% of NZ gross emissions are methane (P163) using the GWP100 measure. **We conclude that 978% of NZ gross emissions are methane.** (770 Mtns compared with 78.7 Mtns)

There is no hope of sequestering through forestry this amount of warming caused by methane. The main problem confronting New Zealand is facing up to the fact that the current method of measuring the warming effect of methane is a fraud designed to hide the true horror of our situation.

> Another way of looking at this is to ask what our share of global emissions should be. NZ with 0.066% of the world's population, we should be able to emit 0.066% of the world's ghg into the commons, which belongs to everyone. Let's see how we do.
>
> **CO2:** The world CO2 emissions are around 35 billion tonnes per year, so NZ should be allowed 0.066% of this or 23.1 million tonnes. We emitted 34 Mtns, so we are a little bit over. But when you take our sink into account we emitted 11.9 net, which is well under our allowance.
>
> **CH4:** Methane is a totally different story though: The world's methane emission in 2016 was about 7.8 billion tonnes of **CO2e** and our share of that would be (0.066% of 7,8Gtns) 5.1 Mtns. But we emitted 33.8 Mtns of CO2e of methane according to the inventory, (using GWP100), which is 6.5 times our allowed amount, a huge over-emission. If we use the true measure of Methane's effect, we are hideously more above our quota.

Concluding summary

The way that we measure the warming effect of methane is vastly more important than whatever target we choose for 2050. The fact can not be ignored that every year since 1990 NZ has emitted around 1 Mtn of methane. Science accepts that a Mtn of methane has a warming effect in the year of its emission of 120 times that of CO_2. Therefore, every year since 1990, NZ's Mtn of methane has caused the equivalent warming of 120Mtn of CO_2.

Thus, our gross CO_2 emissions of 34 Mtns in 2016 are about one quarter of our methane emissions. Our net CO_2 emissions in 2016 of 11.9Mtns are one tenth of our methane emissions. Calling methane a short-lived gas is merely an emotive smokescreen.

New Zealand's huge problem is reducing methane, not reducing CO_2. In other words, the whole consultation/proposal by the government has things totally back to front and is therefore a sham.