Olavi H. Koskinen

Transport modes and energy solutions, physics and resistances

Table 1A. Primary energy use of trucks by alternatives
Rated engine power 250 kW

RATED ENGINE POWER 250 kW				CONVERTED PRIMARY ENERGY CONSUMPTION							
	PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET SPEED	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY
#	t	t	km/h	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm
7	50	31.7	40	40.41	457.0	40.45	454.0	39.98	403.8	39.98	404.5
7	50	31.7	50	49.90	439.7	50.08	421.9	49.97	389.7	49.97	383.0
7	50	31.7	60	59.24	434.8	59.30	426.5	59.95	388.2	59.95	379.0
7	50	31.7	70	68.33	443.5	68.78	460.7	69.78	406.0	69.91	432.2
7	50	31.7	80	77.33	468.1	78.20	495.6	79.64	443.1	79.86	480.2
7	50	31.7	90	86.27	504.7	87.33	529.6	89.38	497.5	89.60	524.3
7	60	41.7	40	40.09	387.8	40.17	384.7	39.98	334.5	39.98	334.8
7	60	41.7	50	49.37	373.5	49.57	361.3	49.96	324.1	49.96	318.7
7	60	41.7	60	**58.44**	**367.8**	**58.57**	**361.2**	59.92	325.2	59.94	317.0
7	60	41.7	70	67.32	372.2	67.86	383.1	69.53	339.4	69.89	357.2
7	60	41.7	80	**76.02**	**387.6**	**77.11**	**406.1**	79.13	366.6	79.67	393.3
7	60	41.7	90	84.79	412.1	86.09	429.1	88.69	404.7	89.22	423.8
8	70	48.8	40	39.67	369.8	39.78	366.1	39.97	313.2	39.97	313.1
8	70	48.8	50	48.67	356.1	48.93	345.8	49.96	305.4	49.96	300.0
8	70	48.8	60	57.42	349.2	57.58	343.0	59.70	307.3	59.82	299.6
8	70	48.8	70	66.09	350.9	66.71	358.1	69.16	320.1	69.69	333.0
8	70	48.8	80	74.45	361.1	75.71	374.8	78.39	341.8	79.35	362.6
8	70	48.8	90	82.88	378.5	84.54	392.2	87.45	371.3	88.57	386.6
10	80	57.6	40	39.15	349.6	39.28	345.5	39.97	292.3	39.97	291.7
10	80	57.6	50	47.79	336.3	48.13	327.8	49.92	287.1	49.96	281.9
10	80	57.6	60	56.35	328.4	56.52	322.6	59.44	289.4	59.56	282.1
10	80	57.6	70	64.64	327.9	65.42	332.4	68.69	300.6	69.34	309.1
10	80	57.6	80	72.58	334.3	74.22	344.2	77.22	317.3	78.78	332.8
10	80	57.6	90	80.55	346.3	82.56	356.4	85.60	339.7	87.52	351.9
10	100	77.6	40	38.05	303.3	38.21	299.4	40.02	247.4	40.04	245.8
10	100	77.6	50	46.21	289.9	46.57	283.9	49.59	244.2	49.73	238.8
10	100	77.6	60	54.23	281.1	54.42	276.2	58.79	246.4	58.93	240.2
10	100	77.6	70	62.24	277.4	62.83	279.1	67.46	254.4	68.30	257.7
10	100	77.6	80	69.68	279.6	71.19	284.3	75.23	265.2	77.15	273.0
10	100	77.6	90	76.42	284.8	78.93	290.6	81.76	277.4	84.97	285.1
10	120	97.6	40	36.81	274.2	37.01	270.5	39.87	219.3	39.93	217.2
10	120	97.6	50	44.51	260.4	44.86	255.5	49.19	216.7	49.38	211.8
10	120	97.6	60	52.10	250.5	52.33	246.4	57.92	218.5	58.06	213.1
10	120	97.6	70	59.59	245.6	60.24	245.3	65.91	224.5	66.81	225.1
10	120	97.6	80	66.44	245.1	68.13	246.9	72.48	231.3	74.99	235.4
10	120	97.6	90	72.35	246.8	75.35	250.2	77.71	238.1	81.50	243.0
10	140	117.6	40	35.48	253.2	35.74	249.6	39.62	199.2	39.67	196.9
10	140	117.6	50	42.75	239.0	43.20	234.6	48.58	196.9	48.83	192.6
10	140	117.6	60	50.01	228.3	50.34	224.6	56.78	198.2	56.97	193.4
10	140	117.6	70	57.06	222.4	57.79	221.3	64.16	202.4	65.07	201.7
10	140	117.6	80	63.12	220.4	65.09	220.8	69.22	206.5	72.22	208.8
10	140	117.6	90	68.17	220.0	71.40	221.9	73.38	210.6	77.47	213.8

Table 1B. Primary energy use of trucks by alternatives
Rated engine power 346 kW

RATED ENGINE POWER 346 kW				CONVERTED PRIMARY ENERGY CONSUMPTION							
PROFILE				ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO				3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET SPEED	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY
#	t	t	km/h	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm
7	50	31.7	40	40.53	508.7	40.56	512.6	39.98	468.2	39.98	473.7
7	50	31.7	50	50.37	477.1	50.49	433.0	49.97	440.3	49.97	433.7
7	50	31.7	60	60.03	447.4	60.06	449.3	59.95	410.7	59.95	414.1
7	50	31.7	70	69.55	441.1	69.74	481.7	69.93	405.4	69.93	456.0
7	50	31.7	80	78.99	481.8	79.38	524.9	79.91	467.7	79.91	508.9
7	50	31.7	90	88.50	517.0	88.91	574.4	89.84	511.4	89.85	567.5
7	60	41.7	40	40.48	422.3	40.53	424.7	39.98	382.5	39.98	387.5
7	60	41.7	50	50.16	397.5	**50.31**	**367.4**	49.96	362.6	49.96	357.5
7	60	41.7	60	59.64	374.1	59.70	374.8	59.94	339.7	59.94	342.3
7	60	41.7	70	**69.01**	**368.5**	69.30	397.0	69.91	335.7	69.92	374.7
7	60	41.7	80	**78.31**	**395.6**	**78.86**	**427.5**	79.85	382.8	79.87	415.4
7	60	41.7	90	87.64	419.9	88.26	462.8	89.70	414.6	89.79	457.5
8	70	48.8	40	40.32	395.2	40.39	396.6	39.97	353.7	39.97	358.5
8	70	48.8	50	49.80	372.8	50.00	350.1	49.96	337.3	49.96	332.9
8	70	48.8	60	59.15	351.8	59.24	351.7	59.93	317.0	59.93	319.1
8	70	48.8	70	68.29	346.4	68.72	368.2	69.76	314.0	69.90	347.2
8	70	48.8	80	77.44	366.1	78.19	392.2	79.65	352.5	79.83	381.1
8	70	48.8	90	86.53	384.2	87.45	420.4	89.43	379.2	89.61	415.8
10	80	57.6	40	40.05	367.7	40.12	368.3	39.97	325.9	39.97	330.4
10	80	57.6	50	49.35	347.2	49.54	330.9	49.95	312.2	49.95	308.4
10	80	57.6	60	58.46	328.4	58.57	327.6	59.92	294.5	59.92	296.1
10	80	57.6	70	67.43	323.2	67.92	339.4	69.56	292.9	69.87	319.8
10	80	57.6	80	76.35	336.3	77.25	357.5	79.30	323.2	79.68	348.0
10	80	57.6	90	85.33	350.5	86.42	379.9	88.95	345.6	89.33	377.0
10	100	77.6	40	39.43	312.1	39.50	311.8	39.96	270.1	39.97	273.7
10	100	77.6	50	48.33	294.6	48.54	283.9	49.95	259.5	49.95	256.6
10	100	77.6	60	57.05	279.0	57.20	277.1	59.65	246.7	59.77	246.6
10	100	77.6	70	65.70	272.8	66.31	282.5	69.11	246.3	69.58	263.9
10	100	77.6	80	74.24	278.6	75.38	292.8	78.35	265.1	79.23	283.7
10	100	77.6	90	82.82	286.0	84.33	306.9	87.53	280.3	88.53	303.9
10	120	97.6	40	38.64	277.8	38.77	276.6	40.01	235.0	40.00	237.8
10	120	97.6	50	47.15	261.6	47.44	254.2	49.85	225.8	49.95	221.1
10	120	97.6	60	55.59	247.6	55.75	245.4	59.33	216.7	59.47	215.7
10	120	97.6	70	63.98	240.6	64.55	246.6	68.54	216.7	69.11	228.3
10	120	97.6	80	72.02	242.3	73.46	252.5	77.10	228.8	78.50	242.9
10	120	97.6	90	80.30	246.2	81.98	261.4	85.63	239.5	87.35	258.1
10	140	117.6	40	37.74	253.9	37.99	252.5	40.06	209.6	40.10	211.5
10	140	117.6	50	45.92	238.1	46.32	232.7	49.64	202.2	49.81	196.7
10	140	117.6	60	54.04	225.0	54.30	222.7	58.89	194.9	59.04	193.4
10	140	117.6	70	62.23	217.0	62.85	221.1	67.71	194.9	68.44	202.9
10	140	117.6	80	70.08	216.7	71.49	224.0	75.90	203.4	77.49	214.1
10	140	117.6	90	77.69	218.3	79.72	230.1	83.41	211.1	85.85	225.7

Table 1C. Primary energy use of trucks by alternatives
Rated engine power 456 kW

RATED ENGINE POWER 456 kW				CONVERTED PRIMARY ENERGY CONSUMPTION							
	PROFILE		ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO		3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET SPEED	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY	AVG SPEED	PRIMARY ENERGY
#	t	t	km/h	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm	km/h	kJ/tkm
7	50	31.7	40	40.51	580.1	40.53	585.5	39.98	543.8	39.98	548.2
7	50	31.7	50	50.51	531.9	50.60	460.1	49.98	495.8	49.97	486.9
7	50	31.7	60	60.41	485.1	60.38	488.8	59.96	448.7	59.96	451.9
7	50	31.7	70	70.17	467.1	70.18	526.0	69.94	430.0	69.95	494.3
7	50	31.7	80	79.85	518.0	79.95	577.0	79.93	496.2	79.93	551.4
7	50	31.7	90	89.58	556.3	89.67	634.5	89.89	540.5	89.89	618.4
7	60	41.7	40	40.58	475.3	40.59	479.2	39.98	439.1	39.98	443.6
7	60	41.7	50	50.49	438.3	**50.62**	**390.0**	49.97	403.7	49.97	397.0
7	60	41.7	60	60.31	402.7	60.30	405.3	59.95	367.8	59.96	370.7
7	60	41.7	70	**69.94**	**389.0**	70.04	431.9	69.93	354.0	69.94	404.0
7	60	41.7	80	**79.56**	**424.5**	**79.75**	**468.9**	79.90	406.7	79.91	449.1
7	60	41.7	90	89.24	451.8	89.42	510.7	89.87	439.1	89.87	497.6
8	70	48.8	40	40.58	439.0	40.60	442.0	39.98	400.8	39.98	405.7
8	70	48.8	50	50.41	407.1	50.52	371.8	49.97	372.1	49.97	366.4
8	70	48.8	60	60.07	376.1	60.10	378.0	59.95	340.7	59.95	343.4
8	70	48.8	70	69.63	364.5	69.79	399.2	69.92	329.3	69.92	372.8
8	70	48.8	80	79.13	391.7	79.47	429.0	79.88	374.9	79.89	411.4
8	70	48.8	90	88.73	413.5	89.05	463.4	89.84	402.4	89.84	452.0
10	80	57.6	40	40.51	403.5	40.56	405.7	39.98	365.0	39.98	369.7
10	80	57.6	50	50.20	376.0	50.35	347.0	49.96	341.7	49.96	336.8
10	80	57.6	60	59.73	349.2	59.78	350.1	59.94	314.7	59.94	317.2
10	80	57.6	70	69.18	339.0	69.42	366.5	69.91	305.2	69.91	342.5
10	80	57.6	80	78.57	359.1	79.05	390.1	79.85	343.7	79.86	375.3
10	80	57.6	90	88.05	376.6	88.55	418.2	89.75	367.8	89.79	409.9
10	100	77.6	40	40.23	338.1	40.30	339.1	39.97	299.0	39.97	303.0
10	100	77.6	50	49.67	315.9	49.88	297.8	49.95	282.2	49.95	278.6
10	100	77.6	60	58.99	294.7	59.10	294.4	59.92	261.6	59.93	263.3
10	100	77.6	70	68.15	286.0	68.60	303.7	69.74	254.8	69.88	282.3
10	100	77.6	80	77.39	297.2	78.11	318.8	79.62	281.8	79.81	305.9
10	100	77.6	90	86.61	307.3	87.48	337.6	89.43	299.6	89.59	330.7
10	120	97.6	40	39.86	298.2	39.96	298.2	39.96	258.3	39.96	261.8
10	120	97.6	50	49.05	278.7	49.27	265.5	49.95	244.5	49.96	241.6
10	120	97.6	60	58.05	260.5	58.20	259.7	59.91	227.8	59.96	228.9
10	120	97.6	70	67.07	252.4	67.52	264.4	69.56	223.5	69.81	243.8
10	120	97.6	80	76.04	257.8	76.92	274.3	79.22	242.6	79.60	262.1
10	120	97.6	90	85.19	264.6	86.22	287.5	88.90	256.5	89.26	281.3
10	140	117.6	40	39.43	270.1	39.53	269.5	39.98	229.7	39.97	232.8
10	140	117.6	50	48.31	252.5	48.59	242.9	50.02	217.9	50.04	211.4
10	140	117.6	60	57.13	236.2	57.29	234.9	59.75	204.1	59.86	204.2
10	140	117.6	70	65.92	227.8	66.48	236.6	69.28	201.0	69.66	216.5
10	140	117.6	80	74.71	230.1	75.70	242.8	78.71	215.1	79.32	231.2
10	140	117.6	90	83.63	234.0	84.91	252.5	88.15	225.9	88.78	246.4

Table 2. Primary energy use of diesel trains by alternatives

WAGONS #	GROSS MASS t	LOAD MASS t	LOAD DEG. %	TARGET SPEED km/h	AVG SPEED km/h	CONVERTED PRIMARY ENERGY CONSUMPTION MJ/trainkm	kJ/gross tkm	kJ/net tkm
6	327	84	23.3	40	40.15	57.5	175.9	684.9
6	327	84	23.3	50	50.02	63.5	194.1	755.6
6	327	84	23.3	60	59.01	63.6	194.5	757.3
6	327	84	23.3	70	68.33	71.1	217.4	846.3
6	327	84	23.3	80	77.69	80.8	247.0	961.6
6	327	84	23.3	90	84.83	89.7	274.3	1067.9
11	547	154	23.3	40	39.91	83.0	151.8	539.3
11	547	154	23.3	50	48.44	89.4	163.5	580.6
11	547	154	23.3	60	55.49	93.4	170.7	606.3
11	547	154	23.3	70	61.55	100.9	184.4	655.0
11	547	154	23.3	80	65.77	107.6	196.7	698.8
11	547	154	23.3	90	67.33	110.6	202.2	718.1
9	603	270	50.0	40	39.61	87.5	145.1	324.1
9	603	270	50.0	50	47.87	93.2	154.6	345.3
9	603	270	50.0	60	54.60	96.9	160.7	358.8
9	603	270	50.0	70	60.16	103.6	171.9	383.8
9	603	270	50.0	**80**	**64.12**	**109.6**	**181.8**	**406.0**
9	603	270	50.0	90	65.35	112.1	185.9	415.2
12	663	240	33.3	40	39.18	95.5	144.1	398.1
12	663	240	33.3	50	46.98	101.7	153.3	423.6
12	663	240	33.3	60	52.91	106.0	159.9	441.7
12	663	240	33.3	70	56.84	111.5	168.1	464.4
12	663	240	33.3	80	59.29	115.6	174.4	481.8
12	663	240	33.3	90	60.13	117.4	177.1	489.3
9	693	360	66.7	40	39.12	96.7	139.6	268.7
9	693	360	66.7	50	46.84	102.2	147.5	283.8
9	693	360	66.7	60	52.72	105.9	152.9	294.3
9	693	360	66.7	70	56.81	111.1	160.4	308.7
9	693	360	66.7	**80**	**59.54**	**115.4**	**166.6**	**320.7**
9	693	360	66.7	90	60.44	117.2	169.2	325.7
8	783	480	100.0	40	38.59	105.3	134.5	219.3
8	783	480	100.0	50	45.97	110.2	140.7	229.6
8	783	480	100.0	60	51.28	114.1	145.7	237.6
8	783	480	100.0	70	54.50	118.4	151.2	246.6
8	783	480	100.0	**80**	**56.21**	**121.3**	**154.9**	**252.7**
8	783	480	100.0	90	56.90	122.9	156.9	256.0

Table 3. Primary energy use of electric trains by alternatives

WAGONS #	GROSS MASS t	LOAD MASS t	LOAD DEG. %	TARGET SPEED km/h	AVG SPEED km/h	PRIMARY ENERGY CONSUMPTION MJ/trainkm	kJ/gross tkm	kJ/net tkm
10	583	200	33.3	40	39.99	80.6	138.3	403.1
10	583	200	33.3	50	49.98	82.2	141.0	411.0
10	583	200	33.3	60	59.98	89.9	154.2	449.4
10	583	200	33.3	70	69.98	97.8	167.8	489.0
10	583	200	33.3	80	79.97	107.8	185.0	539.2
10	583	200	33.3	90	89.97	119.8	205.4	598.8
10	783	400	66.7	40	39.99	97.5	124.5	243.7
10	783	400	66.7	50	49.98	99.9	127.6	249.7
10	783	400	66.7	60	59.98	109.1	139.4	272.8
10	783	400	66.7	70	69.98	119.0	152.0	297.5
10	783	400	66.7	**80**	**79.97**	**131.5**	**167.9**	**328.7**
10	783	400	66.7	90	89.97	146.0	186.5	365.1
15	833	300	33.3	40	39.98	103.2	123.9	344.0
15	833	300	33.3	50	49.98	106.9	128.3	356.2
15	833	300	33.3	60	59.97	117.9	141.5	392.9
15	833	300	33.3	70	69.97	129.9	156.0	433.1
15	833	300	33.3	80	79.96	145.1	174.2	483.8
15	833	300	33.3	90	89.96	162.8	195.5	542.7
10	983	600	100.0	40	39.99	114.6	116.6	191.1
10	983	600	100.0	50	49.98	117.9	120.0	196.5
10	983	600	100.0	60	59.98	128.7	130.9	214.5
10	983	600	100.0	70	69.98	140.6	143.0	234.3
10	983	600	100.0	**80**	**79.97**	**155.5**	**158.2**	**259.2**
10	983	600	100.0	90	89.97	172.7	175.7	287.8
20	1083	400	33.3	40	39.98	125.8	116.1	314.4
20	1083	400	33.3	50	49.97	131.7	121.6	329.1
20	1083	400	33.3	60	59.96	146.1	134.9	365.2
20	1083	400	33.3	70	69.96	162.4	149.9	405.9
20	1083	400	33.3	80	79.95	182.8	168.7	456.9
20	1083	400	33.3	90	89.94	206.2	190.4	515.5
15	1133	600	66.7	40	39.98	128.8	113.7	214.7
15	1133	600	66.7	50	49.98	133.9	118.2	223.2
15	1133	600	66.7	60	59.97	147.3	130.0	245.4
15	1133	600	66.7	70	69.97	162.3	143.3	270.5
15	1133	600	66.7	**80**	**79.96**	**181.1**	**159.9**	**301.9**
15	1133	600	66.7	90	89.96	202.7	178.9	337.9
25	1333	500	33.3	40	39.97	148.2	111.2	296.5
25	1333	500	33.3	50	49.96	156.5	117.4	313.1
25	1333	500	33.3	60	59.95	174.4	130.8	348.8
25	1333	500	33.3	70	69.95	195.1	146.3	390.2
25	1333	500	33.3	80	79.94	220.7	165.6	441.4
25	1333	500	33.3	90	89.93	249.9	187.5	499.8
28	1427	504	30.0	40	39.97	156.9	110.0	311.3
28	1427	504	30.0	50	49.96	166.4	116.6	330.1
28	1427	504	30.0	60	59.95	185.9	130.3	368.9
28	1427	504	30.0	70	69.94	208.7	146.3	414.1
28	1427	504	30.0	80	79.93	236.8	166.0	469.9
28	1427	504	30.0	90	89.92	268.7	188.3	533.2

Table 3. Primary energy use of electric trains by alternatives (cont)

WAGONS #	GROSS MASS t	LOAD MASS t	LOAD DEG. %	TARGET SPEED km/h	AVG SPEED km/h	PRIMARY ENERGY CONSUMPTION MJ/trainkm	kJ/gross tkm	kJ/net tkm
15	1433	900	100.0	40	39.98	155.0	108.1	172.2
15	1433	900	100.0	50	49.98	161.5	112.7	179.5
15	1433	900	100.0	60	59.97	177.2	123.7	196.9
15	1433	900	100.0	70	69.97	195.4	136.3	217.1
15	1433	900	100.0	**80**	**79.96**	**217.8**	**152.0**	**242.0**
15	1433	900	100.0	90	89.96	243.2	169.7	270.2
20	1483	800	66.7	40	39.98	160.2	108.0	200.3
20	1483	800	66.7	50	49.97	168.2	113.4	210.2
20	1483	800	66.7	60	59.96	185.7	125.3	232.2
20	1483	800	66.7	70	69.96	206.2	139.0	257.7
20	1483	800	66.7	**80**	**79.95**	**231.4**	**156.0**	**289.2**
20	1483	800	66.7	90	89.94	259.9	175.3	324.9
30	1583	600	33.3	40	39.96	170.6	107.8	284.4
30	1583	600	33.3	50	49.95	181.5	114.6	302.5
30	1583	600	33.3	60	59.95	202.9	128.2	338.2
30	1583	600	33.3	70	69.94	228.1	144.1	380.2
30	1583	600	33.3	80	79.93	259.0	163.6	431.7
30	1583	600	33.3	90	89.92	293.9	185.7	489.8
25	1833	1000	66.7	40	39.97	191.5	104.5	191.5
25	1833	1000	66.7	50	49.96	202.7	110.6	202.7
25	1833	1000	66.7	60	59.95	224.6	122.5	224.6
25	1833	1000	66.7	70	69.95	250.7	136.8	250.7
25	1833	1000	66.7	**80**	**79.94**	**282.4**	**154.1**	**282.4**
25	1833	1000	66.7	90	89.93	317.8	173.4	317.8
20	1883	1200	100.0	40	39.98	195.3	103.7	162.8
20	1883	1200	100.0	50	49.97	205.7	109.2	171.4
20	1883	1200	100.0	60	59.96	226.5	120.3	188.7
20	1883	1200	100.0	70	69.96	251.2	133.4	209.3
20	1883	1200	100.0	**80**	**79.95**	**281.2**	**149.4**	**234.4**
20	1883	1200	100.0	90	89.94	314.5	167.0	262.1
30	2183	1200	66.7	40	39.96	222.8	102.1	185.7
30	2183	1200	66.7	50	49.95	237.6	108.8	198.0
30	2183	1200	66.7	60	59.95	264.2	121.0	220.1
30	2183	1200	66.7	70	69.94	296.3	135.7	246.9
30	2183	1200	66.7	**80**	**79.93**	**334.5**	**153.2**	**278.7**
30	2183	1200	66.7	90	89.92	377.6	173.0	314.7
25	2333	1500	100.0	40	39.97	235.9	101.1	157.2
25	2333	1500	100.0	50	49.96	250.6	107.4	167.0
25	2333	1500	100.0	60	59.96	276.9	118.7	184.6
25	2333	1500	100.0	70	69.95	308.6	132.3	205.7
25	2333	1500	100.0	**80**	**79.94**	**346.5**	**148.5**	**231.0**
25	2333	1500	100.0	90	89.93	389.7	167.0	259.8
30	2483	1500	83.3	40	39.96	249.8	100.6	166.6
30	2483	1500	83.3	50	49.96	267.3	107.6	178.2
30	2483	1500	83.3	60	59.95	297.0	119.6	198.0
30	2483	1500	83.3	70	69.94	333.7	134.4	222.5
30	2483	1500	83.3	**80**	**79.93**	**376.8**	**151.8**	**251.2**
30	2483	1500	83.3	90	89.90	426.6	171.8	284.4

Table 4. Primary energy use of average electric trains by locomotives and loading alternatives

Electric freight trains
Section Helsinki-Oulu

Loc type	loc	wagons	Gross mass	Load mass	Target speed	Average speed	**Primary energy consumption**		
	#	#	t	t	km/h	km/h	MJ/train km	kJ/gross tkm	kJ/net tkm
Sr1	1	29	1437	646	40	40.0	146.7	102.1	227.0
Sr1	1	29	1437	646	50	50.0	160.5	111.7	248.5
Sr1	1	29	1437	646	60	59.9	176.1	122.5	272.5
Sr1	1	29	1437	646	70	69.9	199.0	138.5	308.1
Sr1	1	29	1437	646	80	79.9	227.7	158.6	352.5
Sr1	1	29	1437	646	90	88.6	259.1	180.3	401.1
Sr2	1	29	1436	646	40	40.0	157.8	110.0	244.4
Sr2	1	29	1436	646	50	50.0	167.6	116.8	259.5
Sr2	1	29	1436	646	60	59.9	187.5	130.6	290.3
Sr2	1	29	1436	646	70	69.9	210.7	146.9	326.4
Sr2	1	29	1436	646	80	79.9	239.5	166.7	370.6
Sr2	1	29	1436	646	90	89.9	272.0	189.4	421.1
Sr1	2	29	2778	1740	40	40.0	275.4	99.0	158.2
Sr1	2	29	2778	1740	50	50.0	296.4	106.6	170.3
Sr1	2	29	2778	1740	60	59.9	319.0	114.9	183.3
Sr1	2	29	2778	1740	70	69.9	354.4	127.6	203.6
Sr1	2	29	2778	1740	80	79.9	398.6	143.5	229.1
Sr1	2	29	2778	1740	90	89.9	453.4	163.1	260.6
Sr2	2	29	2776	1740	40	40.0	295.6	106.4	169.9
Sr2	2	29	2776	1740	50	50.0	307.9	110.9	176.9
Sr2	2	29	2776	1740	60	59.9	338.3	121.9	194.5
Sr2	2	29	2776	1740	70	69.9	372.9	134.4	214.3
Sr2	2	29	2776	1740	80	79.9	416.0	149.9	239.1
Sr2	2	29	2776	1740	90	89.9	465.1	167.5	267.2

Table 5A. Emissions of nitrogen oxides of trucks by alternatives
Rated engine power 250 kW

RATED ENGINE POWER 250 kW			POLLUTANT EMISSIONS OF NITROGEN OXIDES							
PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.41	333.075	40.45	314.032	39.98	314.617	39.98	288.742
7	50	31.7	50	49.90	312.918	50.08	303.835	49.97	297.935	49.97	279.383
7	50	31.7	60	59.24	303.006	59.30	298.336	59.95	295.095	59.95	288.788
7	50	31.7	70	68.33	296.910	68.78	279.542	69.78	283.049	69.91	232.392
7	50	31.7	80	77.33	307.710	78.20	291.950	79.64	299.132	79.86	227.075
7	50	31.7	90	86.27	320.285	87.33	344.807	89.38	294.329	89.60	284.796
7	60	41.7	40	40.09	279.170	40.17	265.155	39.98	259.235	39.98	238.934
7	60	41.7	50	49.37	261.857	49.57	253.639	49.96	246.260	49.96	231.335
7	60	41.7	60	58.44	251.339	58.57	248.861	59.92	238.404	59.94	236.226
7	60	41.7	70	67.32	246.614	67.86	237.619	69.53	228.090	69.89	198.886
7	60	41.7	80	76.02	253.567	77.11	248.660	79.13	242.927	79.67	201.622
7	60	41.7	90	84.79	265.960	86.09	291.593	88.69	248.650	89.22	252.463
8	70	48.8	40	39.67	262.937	39.78	251.583	39.97	240.900	39.97	222.545
8	70	48.8	50	48.67	246.788	48.93	239.772	49.96	228.454	49.96	216.353
8	70	48.8	60	57.42	235.687	57.58	232.783	59.70	217.031	59.82	216.909
8	70	48.8	70	66.09	230.457	66.71	225.524	69.16	209.485	69.69	191.555
8	70	48.8	80	74.45	235.189	75.71	236.638	78.39	223.709	79.35	198.850
8	70	48.8	90	82.88	248.658	84.54	275.198	87.45	236.207	88.57	249.115
10	80	57.6	40	39.15	245.586	39.28	236.672	39.97	222.783	39.97	207.326
10	80	57.6	50	47.79	230.495	48.13	225.172	49.92	209.724	49.96	200.311
10	80	57.6	60	56.35	219.962	56.52	217.669	59.44	198.439	59.56	198.285
10	80	57.6	70	64.64	214.536	65.42	212.706	68.69	194.363	69.34	182.578
10	80	57.6	80	72.58	218.398	74.22	224.078	77.22	206.158	78.78	194.513
10	80	57.6	90	80.55	230.211	82.56	255.447	85.60	222.444	87.52	242.163
10	100	77.6	40	38.05	210.086	38.21	204.181	40.02	182.105	40.04	172.713
10	100	77.6	50	46.21	196.917	46.57	194.185	49.59	171.322	49.73	164.268
10	100	77.6	60	54.23	187.097	54.42	184.477	58.79	164.128	58.93	163.405
10	100	77.6	70	62.24	181.901	62.83	182.058	67.46	162.672	68.30	158.369
10	100	77.6	80	69.68	184.747	71.19	189.020	75.23	172.802	77.15	171.197
10	100	77.6	90	76.42	191.236	78.93	212.360	81.76	185.663	84.97	208.075
10	120	97.6	40	36.81	188.844	37.01	184.691	39.87	156.506	39.93	149.299
10	120	97.6	50	44.51	175.884	44.86	173.996	49.19	148.805	49.38	143.267
10	120	97.6	60	52.10	166.508	52.33	164.545	57.92	143.969	58.06	142.279
10	120	97.6	70	59.59	160.912	60.24	160.890	65.91	143.141	66.81	141.993
10	120	97.6	80	66.44	161.866	68.13	167.822	72.48	150.504	74.99	155.773
10	120	97.6	90	72.35	167.308	75.35	184.492	77.71	160.177	81.50	179.908
10	140	117.6	40	35.48	172.577	35.74	169.500	39.62	138.781	39.67	133.005
10	140	117.6	50	42.75	160.798	43.20	159.372	48.58	133.421	48.83	129.052
10	140	117.6	60	50.01	151.996	50.34	150.200	56.78	129.546	56.97	127.842
10	140	117.6	70	57.06	146.176	57.79	146.981	64.16	130.432	65.07	130.545
10	140	117.6	80	63.12	145.970	65.09	151.418	69.22	134.267	72.22	141.811
10	140	117.6	90	68.17	148.570	71.40	162.254	73.38	140.819	77.47	157.199

Table 5B. Emissions of nitrogen oxides of trucks by alternatives
Rated engine power 346 kW

RATED ENGINE POWER 346 kW				POLLUTANT EMISSIONS OF NITROGEN OXIDES							
PROFILE				ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO				3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.53	339.843	40.56	280.355	39.98	311.067	39.98	248.169
7	50	31.7	50	50.37	303.873	50.49	383.779	49.97	259.279	49.97	228.542
7	50	31.7	60	60.03	340.058	60.06	295.485	59.95	299.062	59.95	242.895
7	50	31.7	70	69.55	384.562	69.74	273.746	69.93	364.569	69.93	211.955
7	50	31.7	80	78.99	308.362	79.38	277.213	79.91	223.385	79.91	207.189
7	50	31.7	90	88.50	322.488	88.91	293.858	89.84	251.261	89.85	227.671
7	60	41.7	40	40.48	285.701	40.53	239.760	39.98	249.454	39.98	198.101
7	60	41.7	50	50.16	258.716	50.31	312.351	49.96	209.353	49.96	184.657
7	60	41.7	60	59.64	287.578	59.70	254.652	59.94	242.568	59.94	197.365
7	60	41.7	70	69.01	320.749	69.30	238.064	69.91	301.771	69.92	175.620
7	60	41.7	80	78.31	266.665	78.86	241.211	79.85	196.912	79.87	177.201
7	60	41.7	90	87.64	275.556	88.26	250.817	89.70	217.655	89.79	194.372
8	70	48.8	40	40.32	269.125	40.39	230.804	39.97	225.100	39.97	179.273
8	70	48.8	50	49.80	248.893	50.00	284.021	49.96	191.058	49.96	169.180
8	70	48.8	60	59.15	273.361	59.24	246.121	59.93	227.200	59.93	183.832
8	70	48.8	70	68.29	297.362	68.72	231.287	69.76	281.160	69.90	166.996
8	70	48.8	80	77.44	256.218	78.19	232.526	79.65	195.654	79.83	172.717
8	70	48.8	90	86.53	262.987	87.45	238.720	89.43	212.638	89.61	188.010
10	80	57.6	40	40.05	252.128	40.12	219.545	39.97	202.716	39.97	162.086
10	80	57.6	50	49.35	237.873	49.54	257.780	49.95	174.916	49.95	154.756
10	80	57.6	60	58.46	259.387	58.57	235.232	59.92	216.467	59.92	175.475
10	80	57.6	70	67.43	273.646	67.92	221.168	69.56	258.845	69.87	160.983
10	80	57.6	80	76.35	243.814	77.25	220.855	79.30	193.107	79.68	167.858
10	80	57.6	90	85.33	247.009	86.42	224.936	88.95	207.584	89.33	182.690
10	100	77.6	40	39.43	221.120	39.50	197.151	39.96	163.713	39.97	131.753
10	100	77.6	50	48.33	210.632	48.54	219.636	49.95	151.942	49.95	133.983
10	100	77.6	60	57.05	221.549	57.20	206.922	59.65	186.423	59.77	157.662
10	100	77.6	70	65.70	227.994	66.31	193.663	69.11	214.024	69.58	144.664
10	100	77.6	80	74.24	209.885	75.38	191.855	78.35	175.990	79.23	150.608
10	100	77.6	90	82.82	210.991	84.33	192.673	87.53	185.742	88.53	162.488
10	120	97.6	40	38.64	202.183	38.77	183.532	40.01	145.267	40.00	116.716
10	120	97.6	50	47.15	192.935	47.44	194.875	49.85	141.557	49.95	133.597
10	120	97.6	60	55.59	196.879	55.75	186.097	59.33	165.842	59.47	145.039
10	120	97.6	70	63.98	198.548	64.55	175.549	68.54	184.894	69.11	135.167
10	120	97.6	80	72.02	186.483	73.46	171.724	77.10	162.932	78.50	139.242
10	120	97.6	90	80.30	186.204	81.98	171.425	85.63	170.099	87.35	148.869
10	140	117.6	40	37.74	188.461	37.99	172.622	40.06	135.812	40.10	110.210
10	140	117.6	50	45.92	178.727	46.32	176.669	49.64	132.788	49.81	130.125
10	140	117.6	60	54.04	179.148	54.30	171.132	58.89	151.066	59.04	135.208
10	140	117.6	70	62.23	178.165	62.85	161.262	67.71	165.269	68.44	127.785
10	140	117.6	80	70.08	169.142	71.49	156.496	75.90	152.002	77.49	130.975
10	140	117.6	90	77.69	169.116	79.72	155.165	83.41	156.870	85.85	138.301

Table 5C. Emissions of nitrogen oxides of trucks by alternatives
Rated engine power 456 kW

RATED ENGINE POWER 456 kW			POLLUTANT EMISSIONS OF NITROGEN OXIDES							
PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD TARGET AVG MASS	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.51	391.476	40.53	317.256	39.98	382.909	39.98	304.168
7	50	31.7	50	50.51	330.438	50.60	456.138	49.98	306.322	49.97	270.582
7	50	31.7	60	60.41	370.703	60.38	312.869	59.96	344.644	59.96	278.992
7	50	31.7	70	70.17	416.274	70.18	280.083	69.94	397.955	69.95	236.562
7	50	31.7	80	79.85	297.814	79.95	276.554	79.93	229.218	79.93	221.464
7	50	31.7	90	89.58	313.016	89.67	288.554	89.89	247.297	89.89	228.996
7	60	41.7	40	40.58	318.223	40.59	260.236	39.98	300.016	39.98	239.283
7	60	41.7	50	50.49	277.188	50.62	361.708	49.97	244.935	49.97	215.464
7	60	41.7	60	60.31	306.667	60.30	264.633	59.95	276.423	59.96	223.873
7	60	41.7	70	69.94	342.570	70.04	239.228	69.93	322.702	69.94	190.917
7	60	41.7	80	79.56	259.325	79.75	237.176	79.90	188.937	79.91	182.881
7	60	41.7	90	89.24	268.715	89.42	246.864	89.87	204.913	89.87	189.409
8	70	48.8	40	40.58	295.189	40.60	244.505	39.98	267.938	39.98	213.176
8	70	48.8	50	50.41	261.865	50.52	321.649	49.97	220.678	49.97	194.482
8	70	48.8	60	60.07	287.219	60.10	251.029	59.95	250.016	59.95	203.249
8	70	48.8	70	69.63	317.390	69.79	229.962	69.92	296.481	69.92	174.964
8	70	48.8	80	79.13	252.156	79.47	228.713	79.88	178.827	79.89	168.817
8	70	48.8	90	88.73	258.330	89.05	237.495	89.84	195.159	89.84	178.672
10	80	57.6	40	40.51	273.185	40.56	229.333	39.98	238.925	39.98	189.751
10	80	57.6	50	50.20	245.188	50.35	295.370	49.96	198.422	49.96	175.031
10	80	57.6	60	59.73	268.757	59.78	237.882	59.94	225.583	59.94	184.004
10	80	57.6	70	69.18	293.006	69.42	219.352	69.91	273.610	69.91	160.870
10	80	57.6	80	78.57	240.965	79.05	218.300	79.85	172.640	79.86	158.164
10	80	57.6	90	88.05	244.372	88.55	224.528	89.75	188.231	89.79	170.675
10	100	77.6	40	40.23	231.968	40.30	200.570	39.97	189.614	39.97	151.014
10	100	77.6	50	49.67	213.946	49.88	239.553	49.95	159.669	49.95	141.511
10	100	77.6	60	58.99	230.165	59.10	208.980	59.92	188.206	59.93	152.882
10	100	77.6	70	68.15	245.193	68.60	193.995	69.74	228.541	69.88	137.147
10	100	77.6	80	77.39	209.883	78.11	191.784	79.62	157.189	79.81	139.746
10	100	77.6	90	86.61	211.038	87.48	193.072	89.43	167.075	89.59	149.660
10	120	97.6	40	39.86	207.907	39.96	182.870	39.96	159.647	39.96	128.234
10	120	97.6	50	49.05	195.631	49.27	211.952	49.95	138.851	49.96	121.481
10	120	97.6	60	58.05	206.214	58.20	189.806	59.91	169.320	59.96	138.805
10	120	97.6	70	67.07	213.006	67.52	176.631	69.56	197.737	69.81	125.821
10	120	97.6	80	76.04	189.528	76.92	173.154	79.22	147.438	79.60	128.782
10	120	97.6	90	85.19	187.746	86.22	172.445	88.90	154.022	89.26	137.027
10	140	117.6	40	39.43	192.836	39.53	172.690	39.98	139.624	39.97	112.823
10	140	117.6	50	48.31	181.960	48.59	190.046	50.02	128.072	50.04	125.849
10	140	117.6	60	57.13	188.667	57.29	175.818	59.75	155.443	59.86	130.749
10	140	117.6	70	65.92	190.844	66.48	162.868	69.28	175.801	69.66	118.205
10	140	117.6	80	74.71	172.864	75.70	159.070	78.71	139.750	79.32	120.862
10	140	117.6	90	83.63	170.997	84.91	156.938	88.15	144.319	88.78	127.705

Table 5D. Emissions of nitrogen oxides of diesel trains by alternatives

WAGONS	GROSS MASS	LOAD MASS	LOAD DEG.	TARGET SPEED	AVG SPEED	NO_x EMISSIONS		
#	t	t	%	km/h	km/h	g/trainkm	mg/gross tkm	mg/net tkm
6	327	84	23.3	40	40.15	120.620	368.869	1435.954
6	327	84	23.3	50	50.02	116.278	355.591	1384.265
6	327	84	23.3	60	59.01	128.641	393.397	1531.438
6	327	84	23.3	70	68.33	132.130	404.068	1572.978
6	327	84	23.3	80	77.69	130.352	398.629	1551.807
6	327	84	23.3	90	84.83	126.889	388.038	1510.578
11	547	154	23.3	40	39.91	164.417	300.580	1067.644
11	547	154	23.3	50	48.44	167.260	305.777	1086.105
11	547	154	23.3	60	55.49	181.910	332.559	1181.232
11	547	154	23.3	70	61.55	190.298	347.894	1235.701
11	547	154	23.3	80	65.77	193.247	353.285	1254.851
11	547	154	23.3	90	67.33	193.658	354.036	1257.516
9	603	270	50.0	40	39.61	172.519	286.101	638.960
9	603	270	50.0	50	47.87	174.861	289.986	647.635
9	603	270	50.0	60	54.60	188.183	312.078	696.975
9	603	270	50.0	70	60.16	195.737	324.606	724.953
9	603	270	50.0	80	64.12	198.276	328.815	734.354
9	603	270	50.0	90	65.35	198.713	329.540	735.973
12	663	240	33.3	40	39.18	186.706	281.608	777.943
12	663	240	33.3	50	46.98	190.505	287.337	793.769
12	663	240	33.3	60	52.91	203.254	306.568	846.893
12	663	240	33.3	70	56.84	211.466	318.953	881.107
12	663	240	33.3	80	59.29	214.461	323.471	893.588
12	663	240	33.3	90	60.13	214.755	323.914	894.811
9	693	360	66.7	40	39.12	188.549	272.076	523.747
9	693	360	66.7	50	46.84	191.361	276.134	531.559
9	693	360	66.7	60	52.72	203.122	293.106	564.228
9	693	360	66.7	70	56.81	210.531	303.796	584.807
9	693	360	66.7	80	59.54	213.372	307.896	592.699
9	693	360	66.7	90	60.44	213.643	308.287	593.452
8	783	480	100.0	40	38.59	203.072	259.352	423.067
8	783	480	100.0	50	45.97	205.955	263.034	429.074
8	783	480	100.0	60	51.28	215.571	275.314	449.107
8	783	480	100.0	70	54.50	222.517	284.185	463.576
8	783	480	100.0	80	56.21	225.332	287.781	469.442
8	783	480	100.0	90	56.90	225.658	288.196	470.120

Table 6A. Emissions of carbon monoxide of trucks by alternatives
Rated enginen power 250 kW

RATED ENGINE POWER 250 kW			POLLUTANT EMISSIONS OF CARBON MONOXIDE							
PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD TARGET	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.41	33.441	40.45	34.074	39.98	29.924	39.98	34.363
7	50	31.7	50	49.90	31.386	50.08	32.703	49.97	27.606	49.97	28.683
7	50	31.7	60	59.24	34.140	59.30	30.723	59.95	29.372	59.95	26.195
7	50	31.7	70	68.33	38.689	68.78	27.004	69.78	39.078	69.91	26.860
7	50	31.7	80	77.33	31.524	78.20	22.080	79.64	28.197	79.86	24.423
7	50	31.7	90	86.27	26.522	87.33	19.329	89.38	22.994	89.60	21.799
7	60	41.7	40	40.09	27.807	40.17	27.475	39.98	24.314	39.98	26.793
7	60	41.7	50	49.37	26.227	49.57	26.832	49.96	22.495	49.96	22.799
7	60	41.7	60	58.44	28.829	58.57	25.696	59.92	25.448	59.94	21.808
7	60	41.7	70	67.32	31.391	67.86	21.740	69.53	33.623	69.89	20.206
7	60	41.7	80	76.02	26.099	77.11	17.267	79.13	23.888	79.67	17.392
7	60	41.7	90	84.79	21.257	86.09	14.952	88.69	18.805	89.22	16.455
8	70	48.8	40	39.67	26.107	39.78	25.272	39.97	22.338	39.97	23.585
8	70	48.8	50	48.67	24.717	48.93	24.799	49.96	20.890	49.96	20.652
8	70	48.8	60	57.42	26.946	57.58	24.534	59.70	25.396	59.82	21.012
8	70	48.8	70	66.09	28.847	66.71	19.859	69.16	31.800	69.69	17.582
8	70	48.8	80	74.45	24.226	75.71	15.754	78.39	22.735	79.35	14.508
8	70	48.8	90	82.88	19.876	84.54	13.233	87.45	18.004	88.57	13.957
10	80	57.6	40	39.15	24.513	39.28	23.001	39.97	20.657	39.97	20.851
10	80	57.6	50	47.79	23.441	48.13	22.587	49.92	19.724	49.96	18.967
10	80	57.6	60	56.35	24.715	56.52	22.406	59.44	24.357	59.56	20.344
10	80	57.6	70	64.64	26.273	65.42	18.105	68.69	28.812	69.34	15.645
10	80	57.6	80	72.58	22.354	74.22	13.918	77.22	21.578	78.78	12.247
10	80	57.6	90	80.55	18.630	82.56	12.033	85.60	16.921	87.52	11.366
10	100	77.6	40	38.05	20.701	38.21	19.114	40.02	17.779	40.04	16.799
10	100	77.6	50	46.21	19.381	46.57	18.162	49.59	17.538	49.73	17.224
10	100	77.6	60	54.23	20.362	54.42	18.825	58.79	20.633	58.93	17.629
10	100	77.6	70	62.24	20.822	62.83	15.016	67.46	23.060	68.30	13.010
10	100	77.6	80	69.68	17.477	71.19	11.569	75.23	17.427	77.15	9.716
10	100	77.6	90	76.42	15.962	78.93	10.104	81.76	14.832	84.97	8.730
10	120	97.6	40	36.81	17.962	37.01	16.592	39.87	16.287	39.93	15.018
10	120	97.6	50	44.51	16.898	44.86	15.754	49.19	15.548	49.38	15.170
10	120	97.6	60	52.10	17.597	52.33	16.235	57.92	17.642	58.06	15.653
10	120	97.6	70	59.59	17.883	60.24	13.383	65.91	19.233	66.81	11.496
10	120	97.6	80	66.44	15.244	68.13	10.351	72.48	15.242	74.99	8.630
10	120	97.6	90	72.35	13.470	75.35	8.765	77.71	13.074	81.50	7.799
10	140	117.6	40	35.48	16.553	35.74	15.271	39.62	14.846	39.67	13.706
10	140	117.6	50	42.75	15.364	43.20	14.168	48.58	13.946	48.83	13.523
10	140	117.6	60	50.01	15.541	50.34	14.464	56.78	15.697	56.97	14.021
10	140	117.6	70	57.06	15.550	57.79	12.230	64.16	16.022	65.07	10.616
10	140	117.6	80	63.12	13.682	65.09	9.815	69.22	13.975	72.22	8.203
10	140	117.6	90	68.17	12.355	71.40	8.333	73.38	12.089	77.47	7.507

Table 6B. Emissions of carbon monoxide of trucks by alternatives
Rated enginen power 346 kW

RATED ENGINE POWER 346 kW				POLLUTANT EMISSIONS OF CARBON MONOXIDE							
	PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.53	26.378	40.56	28.549	39.98	30.273	39.98	33.904
7	50	31.7	50	50.37	22.607	50.49	32.158	49.97	24.840	49.97	26.527
7	50	31.7	60	60.03	19.408	60.06	19.725	59.95	17.604	59.95	20.140
7	50	31.7	70	69.55	25.196	69.74	19.768	69.93	19.278	69.93	21.499
7	50	31.7	80	78.99	17.796	79.38	20.860	79.91	18.554	79.91	24.777
7	50	31.7	90	88.50	17.118	88.91	20.753	89.84	19.084	89.85	23.095
7	60	41.7	40	40.48	20.545	40.53	21.935	39.98	22.628	39.98	25.464
7	60	41.7	50	50.16	17.739	50.31	27.059	49.96	18.546	49.96	19.736
7	60	41.7	60	59.64	15.938	59.70	15.522	59.94	13.259	59.94	15.167
7	60	41.7	70	69.01	21.286	69.30	15.171	69.91	16.734	69.92	16.400
7	60	41.7	80	78.31	14.379	78.86	15.567	79.85	13.982	79.87	17.908
7	60	41.7	90	87.64	13.535	88.26	15.818	89.70	15.038	89.79	17.999
8	70	48.8	40	40.32	18.179	40.39	19.308	39.97	18.981	39.97	21.496
8	70	48.8	50	49.80	15.837	50.00	22.918	49.96	15.616	49.96	16.565
8	70	48.8	60	59.15	14.553	59.24	14.200	59.93	11.439	59.93	13.006
8	70	48.8	70	68.29	20.002	68.72	13.286	69.76	17.626	69.90	14.153
8	70	48.8	80	77.44	12.984	78.19	13.189	79.65	12.305	79.83	15.153
8	70	48.8	90	86.53	12.333	87.45	13.665	89.43	13.211	89.61	15.684
10	80	57.6	40	40.05	15.971	40.12	16.622	39.97	15.886	39.97	17.924
10	80	57.6	50	49.35	14.154	49.54	19.421	49.95	13.211	49.95	13.984
10	80	57.6	60	58.46	13.584	58.57	12.792	59.92	9.958	59.92	11.143
10	80	57.6	70	67.43	18.517	67.92	11.753	69.56	17.357	69.87	12.184
10	80	57.6	80	76.35	12.098	77.25	11.495	79.30	10.952	79.68	12.749
10	80	57.6	90	85.33	10.707	86.42	11.763	88.95	10.908	89.33	12.971
10	100	77.6	40	39.43	12.601	39.50	12.854	39.96	11.726	39.97	13.218
10	100	77.6	50	48.33	11.359	48.54	15.377	49.95	9.878	49.95	10.353
10	100	77.6	60	57.05	11.811	57.20	10.922	59.65	9.100	59.77	8.837
10	100	77.6	70	65.70	15.052	66.31	9.364	69.11	15.761	69.58	9.287
10	100	77.6	80	74.24	9.863	75.38	8.978	78.35	8.993	79.23	9.440
10	100	77.6	90	82.82	8.545	84.33	9.017	87.53	8.254	88.53	9.667
10	120	97.6	40	38.64	11.039	38.77	10.826	40.01	9.253	40.00	10.345
10	120	97.6	50	47.15	10.135	47.44	12.866	49.85	8.507	49.95	9.208
10	120	97.6	60	55.59	10.119	55.75	9.427	59.33	8.487	59.47	7.840
10	120	97.6	70	63.98	12.653	64.55	8.138	68.54	13.500	69.11	7.592
10	120	97.6	80	72.02	8.743	73.46	7.443	77.10	7.835	78.50	7.565
10	120	97.6	90	80.30	7.312	81.98	7.458	85.63	6.895	87.35	7.673
10	140	117.6	40	37.74	10.207	37.99	9.422	40.06	7.747	40.10	8.387
10	140	117.6	50	45.92	9.105	46.32	11.009	49.64	7.496	49.81	9.166
10	140	117.6	60	54.04	9.158	54.30	8.411	58.89	8.041	59.04	7.263
10	140	117.6	70	62.23	10.905	62.85	7.124	67.71	11.955	68.44	6.548
10	140	117.6	80	70.08	7.725	71.49	6.445	75.90	7.063	77.49	6.316
10	140	117.6	90	77.69	6.627	79.72	6.551	83.41	6.166	85.85	6.381

Table 6C. Emissions of carbon monoxide of trucks by alternatives
Rated enginen power 456 kW

RATED ENGINE POWER 456 kW				POLLUTANT EMISSIONS OF CARBON MONOXIDE							
	PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.51	34.501	40.53	38.135	39.98	41.215	39.98	46.360
7	50	31.7	50	50.51	29.121	50.60	37.651	49.98	34.206	49.97	36.206
7	50	31.7	60	60.41	22.620	60.38	24.973	59.96	24.326	59.96	27.996
7	50	31.7	70	70.17	26.682	70.18	26.478	69.94	20.876	69.95	29.991
7	50	31.7	80	79.85	21.066	79.95	28.620	79.93	23.014	79.93	34.352
7	50	31.7	90	89.58	21.176	89.67	27.562	89.89	23.036	89.89	30.922
7	60	41.7	40	40.58	26.010	40.59	28.580	39.98	30.873	39.98	34.589
7	60	41.7	50	50.49	22.395	50.62	30.404	49.97	25.552	49.97	27.092
7	60	41.7	60	60.31	18.108	60.30	18.922	59.95	18.038	59.96	20.767
7	60	41.7	70	69.94	22.645	70.04	19.754	69.93	16.962	69.94	22.185
7	60	41.7	80	79.56	16.448	79.75	20.967	79.90	17.128	79.91	24.665
7	60	41.7	90	89.24	16.178	89.42	20.677	89.87	18.222	89.87	23.569
8	70	48.8	40	40.58	22.649	40.60	24.415	39.98	25.982	39.98	29.097
8	70	48.8	50	50.41	19.471	50.52	27.040	49.97	21.382	49.97	22.723
8	70	48.8	60	60.07	16.628	60.10	16.595	59.95	15.196	59.95	17.493
8	70	48.8	70	69.63	20.930	69.79	16.796	69.92	15.868	69.92	18.664
8	70	48.8	80	79.13	14.593	79.47	17.523	79.88	14.900	79.89	20.821
8	70	48.8	90	88.73	13.912	89.05	17.436	89.84	16.088	89.84	20.224
10	80	57.6	40	40.51	19.668	40.56	21.043	39.98	21.780	39.98	24.472
10	80	57.6	50	50.20	17.014	50.35	25.465	49.96	17.839	49.96	18.983
10	80	57.6	60	59.73	15.067	59.78	14.790	59.94	12.767	59.94	14.670
10	80	57.6	70	69.18	19.475	69.42	14.352	69.91	15.093	69.91	15.770
10	80	57.6	80	78.57	13.307	79.05	14.785	79.85	12.877	79.86	17.251
10	80	57.6	90	88.05	12.232	88.55	14.740	89.75	13.405	89.79	16.517
10	100	77.6	40	40.23	15.484	40.30	16.275	39.97	15.861	39.97	18.001
10	100	77.6	50	49.67	13.453	49.88	18.876	49.95	13.054	49.95	13.859
10	100	77.6	60	58.99	12.461	59.10	11.945	59.92	9.523	59.93	10.818
10	100	77.6	70	68.15	16.501	68.60	10.933	69.74	14.347	69.88	11.774
10	100	77.6	80	77.39	10.668	78.11	10.838	79.62	9.874	79.81	12.523
10	100	77.6	90	86.61	9.946	87.48	11.110	89.43	10.170	89.59	12.332
10	120	97.6	40	39.86	12.772	39.96	13.020	39.96	12.346	39.96	13.951
10	120	97.6	50	49.05	11.153	49.27	16.063	49.95	10.383	49.96	10.994
10	120	97.6	60	58.05	11.122	58.20	10.170	59.91	7.971	59.96	8.672
10	120	97.6	70	67.07	14.141	67.52	9.184	69.56	13.537	69.81	9.385
10	120	97.6	80	76.04	9.426	76.92	8.763	79.22	8.378	79.60	9.869
10	120	97.6	90	85.19	8.111	86.22	9.011	88.90	8.143	89.26	9.830
10	140	117.6	40	39.43	10.980	39.53	11.144	39.98	10.069	39.97	11.322
10	140	117.6	50	48.31	9.882	48.59	13.290	50.02	8.518	50.04	9.769
10	140	117.6	60	57.13	10.004	57.29	9.208	59.75	7.700	59.86	7.545
10	140	117.6	70	65.92	12.436	66.48	7.900	69.28	12.835	69.66	7.837
10	140	117.6	80	74.71	8.080	75.70	7.551	78.71	7.338	79.32	8.146
10	140	117.6	90	83.63	7.058	84.91	7.586	88.15	6.880	88.78	8.208

Table 6D. Emissions of carbon monoxide of diesel trains by alternatives

WAGONS #	GROSS MASS t	LOAD MASS t	LOAD DEG. %	TARGET SPEED km/h	AVG SPEED km/h	CO EMISSIONS g/trainkm	mg/gross tkm	mg/net tkm
6	327	84	23.3	40	40.15	58.857	179.990	700.675
6	327	84	23.3	50	50.02	62.334	190.624	742.072
6	327	84	23.3	60	59.01	59.579	182.198	709.271
6	327	84	23.3	70	68.33	68.014	207.993	809.685
6	327	84	23.3	80	77.69	97.756	298.948	1163.761
6	327	84	23.3	90	84.83	132.631	405.601	1578.946
11	547	154	23.3	40	39.91	86.467	158.076	561.477
11	547	154	23.3	50	48.44	85.702	156.676	556.504
11	547	154	23.3	60	55.49	90.731	165.870	589.162
11	547	154	23.3	70	61.55	96.268	175.992	625.115
11	547	154	23.3	80	65.77	111.223	203.332	722.225
11	547	154	23.3	90	67.33	120.281	219.892	781.043
9	603	270	50.0	40	39.61	90.829	150.628	336.402
9	603	270	50.0	50	47.87	89.386	148.235	331.059
9	603	270	50.0	60	54.60	94.558	156.812	350.214
9	603	270	50.0	70	60.16	99.389	164.825	368.109
9	603	270	50.0	80	64.12	112.237	186.131	415.693
9	603	270	50.0	90	65.35	120.038	199.067	444.583
12	663	240	33.3	40	39.18	99.135	149.525	413.064
12	663	240	33.3	50	46.98	98.160	148.054	408.999
12	663	240	33.3	60	52.91	105.104	158.529	437.935
12	663	240	33.3	70	56.84	108.258	163.285	451.075
12	663	240	33.3	80	59.29	115.181	173.727	479.922
12	663	240	33.3	90	60.13	120.269	181.402	501.122
9	693	360	66.7	40	39.12	100.615	145.188	279.486
9	693	360	66.7	50	46.84	98.927	142.752	274.798
9	693	360	66.7	60	52.72	105.075	151.624	291.876
9	693	360	66.7	70	56.81	108.125	156.024	300.347
9	693	360	66.7	80	59.54	115.444	166.585	320.677
9	693	360	66.7	90	60.44	120.717	174.194	335.324
8	783	480	100.0	40	38.59	109.766	140.186	228.678
8	783	480	100.0	50	45.97	107.045	136.711	223.010
8	783	480	100.0	60	51.28	114.525	146.265	238.594
8	783	480	100.0	70	54.50	117.200	149.681	244.167
8	783	480	100.0	80	56.21	121.955	155.754	254.073
8	783	480	100.0	90	56.90	126.082	161.024	262.671

Table 7A. Emissions of hydro carbons of trucks by alternatives
Rated engine power 250 kW

RATED ENGINE POWER 250 kW				POLLUTANT EMISSIONS OF HYDRO CARBONS							
	PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.41	15.348	40.45	15.936	39.98	16.357	39.98	17.296
7	50	31.7	50	49.90	13.528	50.08	13.748	49.97	14.230	49.97	14.535
7	50	31.7	60	59.24	12.613	59.30	12.278	59.95	12.696	59.95	12.698
7	50	31.7	70	68.33	12.153	68.78	14.671	69.78	11.363	69.91	14.537
7	50	31.7	80	77.33	12.124	78.20	17.072	79.64	12.367	79.86	16.556
7	50	31.7	90	86.27	14.628	87.33	17.464	89.38	14.942	89.60	17.863
7	60	41.7	40	40.09	12.393	40.17	12.777	39.98	12.799	39.98	13.433
7	60	41.7	50	49.37	11.002	49.57	11.225	49.96	11.162	49.96	11.368
7	60	41.7	60	58.44	10.268	58.57	10.029	59.92	9.863	59.94	9.943
7	60	41.7	70	67.32	10.094	67.86	11.816	69.53	8.901	69.89	11.688
7	60	41.7	80	76.02	9.830	77.11	13.657	79.13	9.416	79.67	13.075
7	60	41.7	90	84.79	11.901	86.09	13.838	88.69	12.157	89.22	14.160
8	70	48.8	40	39.67	11.344	39.78	11.634	39.97	11.263	39.97	11.754
8	70	48.8	50	48.67	10.194	48.93	10.472	49.96	9.839	49.96	10.026
8	70	48.8	60	57.42	9.615	57.58	9.273	59.70	8.678	59.82	8.788
8	70	48.8	70	66.09	9.392	66.71	10.769	69.16	8.069	69.69	10.562
8	70	48.8	80	74.45	9.081	75.71	12.333	78.39	8.421	79.35	11.955
8	70	48.8	90	82.88	10.795	84.54	12.449	87.45	11.008	88.57	12.698
10	80	57.6	40	39.15	10.413	39.28	10.642	39.97	9.894	39.97	10.291
10	80	57.6	50	47.79	9.397	48.13	9.752	49.92	8.655	49.96	8.864
10	80	57.6	60	56.35	8.942	56.52	8.683	59.44	7.701	59.56	7.723
10	80	57.6	70	64.64	8.723	65.42	9.816	68.69	7.478	69.34	9.484
10	80	57.6	80	72.58	8.455	74.22	11.273	77.22	7.619	78.78	10.914
10	80	57.6	90	80.55	9.823	82.56	11.141	85.60	9.841	87.52	11.081
10	100	77.6	40	38.05	8.772	38.21	8.934	40.02	7.643	40.04	8.013
10	100	77.6	50	46.21	8.046	46.57	8.437	49.59	6.722	49.73	6.843
10	100	77.6	60	54.23	7.627	54.42	7.350	58.79	6.291	58.93	6.185
10	100	77.6	70	62.24	7.395	62.83	8.061	67.46	6.302	68.30	7.630
10	100	77.6	80	69.68	7.319	71.19	9.140	75.23	6.473	77.15	8.910
10	100	77.6	90	76.42	7.973	78.93	9.021	81.76	7.898	84.97	8.896
10	120	97.6	40	36.81	7.945	37.01	7.991	39.87	6.333	39.93	6.497
10	120	97.6	50	44.51	7.194	44.86	7.479	49.19	5.780	49.38	5.852
10	120	97.6	60	52.10	6.803	52.33	6.582	57.92	5.503	58.06	5.310
10	120	97.6	70	59.59	6.624	60.24	7.038	65.91	5.602	66.81	6.519
10	120	97.6	80	66.44	6.438	68.13	7.837	72.48	5.717	74.99	7.656
10	120	97.6	90	72.35	7.017	75.35	7.733	77.71	6.665	81.50	7.540
10	140	117.6	40	35.48	7.193	35.74	7.200	39.62	5.463	39.67	5.533
10	140	117.6	50	42.75	6.583	43.20	6.780	48.58	5.124	48.83	5.198
10	140	117.6	60	50.01	6.225	50.34	6.024	56.78	5.002	56.97	4.784
10	140	117.6	70	57.06	6.034	57.79	6.330	64.16	5.259	65.07	5.812
10	140	117.6	80	63.12	5.889	65.09	6.899	69.22	5.200	72.22	6.742
10	140	117.6	90	68.17	6.189	71.40	6.818	73.38	5.739	77.47	6.587

Table 7B. Emissions of hydro carbons of trucks by alternatives
Rated engine power 346 kW

RATED ENGINE POWER 346 kW — POLLUTANT EMISSIONS OF HYDRO CARBONS

	PROFILE		ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
	FINAL GEAR RATIO		3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.53	12.260	40.56	13.481	39.98	14.299	39.98	16.143
7	50	31.7	50	50.37	10.257	50.49	9.320	49.97	11.983	49.97	12.605
7	50	31.7	60	60.03	8.159	60.06	8.884	59.95	9.109	59.95	9.918
7	50	31.7	70	69.55	7.217	69.74	10.257	69.93	7.968	69.93	11.498
7	50	31.7	80	78.99	7.430	79.38	9.673	79.91	8.200	79.91	11.350
7	50	31.7	90	88.50	8.490	88.91	9.986	89.84	9.523	89.85	11.462
7	60	41.7	40	40.48	9.285	40.53	10.100	39.98	10.808	39.98	12.116
7	60	41.7	50	50.16	7.765	50.31	7.262	49.96	9.030	49.96	9.451
7	60	41.7	60	59.64	6.292	59.70	6.786	59.94	6.980	59.94	7.497
7	60	41.7	70	69.01	5.633	69.30	7.714	69.91	6.164	69.92	8.671
7	60	41.7	80	78.31	5.701	78.86	7.219	79.85	6.092	79.87	8.367
7	60	41.7	90	87.64	6.416	88.26	7.534	89.70	7.263	89.79	8.742
8	70	48.8	40	40.32	7.993	40.39	8.607	39.97	9.202	39.97	10.220
8	70	48.8	50	49.80	6.708	50.00	6.402	49.96	7.661	49.96	7.973
8	70	48.8	60	59.15	5.527	59.24	5.899	59.93	6.052	59.93	6.421
8	70	48.8	70	68.29	5.018	68.72	6.575	69.76	5.402	69.90	7.411
8	70	48.8	80	77.44	4.988	78.19	6.137	79.65	5.215	79.83	7.095
8	70	48.8	90	86.53	5.498	87.45	6.473	89.43	6.210	89.61	7.507
10	80	57.6	40	40.05	6.896	40.12	7.353	39.97	7.812	39.97	8.581
10	80	57.6	50	49.35	5.797	49.54	5.663	49.95	6.501	49.95	6.727
10	80	57.6	60	58.46	4.851	58.57	5.123	59.92	5.193	59.92	5.462
10	80	57.6	70	67.43	4.470	67.92	5.612	69.56	4.732	69.87	6.305
10	80	57.6	80	76.35	4.363	77.25	5.251	79.30	4.450	79.68	5.971
10	80	57.6	90	85.33	4.726	86.42	5.510	88.95	5.143	89.33	6.143
10	100	77.6	40	39.43	5.242	39.50	5.520	39.96	5.806	39.97	6.287
10	100	77.6	50	48.33	4.455	48.54	4.411	49.95	4.816	49.95	4.957
10	100	77.6	60	57.05	3.843	57.20	3.982	59.65	3.942	59.77	4.055
10	100	77.6	70	65.70	3.546	66.31	4.321	69.11	3.637	69.58	4.720
10	100	77.6	80	74.24	3.423	75.38	3.953	78.35	3.374	79.23	4.392
10	100	77.6	90	82.82	3.592	84.33	4.155	87.53	3.754	88.53	4.502
10	120	97.6	40	38.64	4.313	38.77	4.486	40.01	4.603	40.00	4.933
10	120	97.6	50	47.15	3.692	47.44	3.687	49.85	3.832	49.95	3.885
10	120	97.6	60	55.59	3.250	55.75	3.341	59.33	3.216	59.47	3.264
10	120	97.6	70	63.98	3.005	64.55	3.508	68.54	2.978	69.11	3.721
10	120	97.6	80	72.02	2.885	73.46	3.225	77.10	2.771	78.50	3.493
10	120	97.6	90	80.30	2.954	81.98	3.353	85.63	2.974	87.35	3.543
10	140	117.6	40	37.74	3.727	37.99	3.836	40.06	3.771	40.10	4.000
10	140	117.6	50	45.92	3.213	46.32	3.211	49.64	3.179	49.81	3.199
10	140	117.6	60	54.04	2.853	54.30	2.915	58.89	2.736	59.04	2.761
10	140	117.6	70	62.23	2.628	62.85	2.996	67.71	2.529	68.44	3.075
10	140	117.6	80	70.08	2.529	71.49	2.757	75.90	2.375	77.49	2.889
10	140	117.6	90	77.69	2.535	79.72	2.853	83.41	2.499	85.85	2.930

Table 7C. Emissions of hydro carbons of trucks by alternatives
Rated engine power 456 kW

RATED ENGINE POWER 456 kW — POLLUTANT EMISSIONS OF HYDRO CARBONS

PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.51	16.191	40.53	18.223	39.98	18.927	39.98	21.718
7	50	31.7	50	50.51	13.634	50.60	11.445	49.98	16.083	49.97	17.031
7	50	31.7	60	60.41	10.427	60.38	11.655	59.96	11.840	59.96	13.279
7	50	31.7	70	70.17	8.920	70.18	13.824	69.94	9.907	69.95	15.583
7	50	31.7	80	79.85	9.709	79.95	13.037	79.93	11.007	79.93	15.339
7	50	31.7	90	89.58	10.979	89.67	13.352	89.89	12.151	89.89	15.422
7	60	41.7	40	40.58	12.228	40.59	13.609	39.98	14.369	39.98	16.379
7	60	41.7	50	50.49	10.240	50.62	9.063	49.97	12.115	49.97	12.798
7	60	41.7	60	60.31	7.949	60.30	8.789	59.95	9.010	59.96	9.989
7	60	41.7	70	69.94	6.884	70.04	10.324	69.93	7.666	69.94	11.697
7	60	41.7	80	79.56	7.312	79.75	9.645	79.90	8.122	79.91	11.282
7	60	41.7	90	89.24	8.240	89.42	9.968	89.87	9.337	89.87	11.692
8	70	48.8	40	40.58	10.467	40.60	11.512	39.98	12.254	39.98	13.866
8	70	48.8	50	50.41	8.720	50.52	8.022	49.97	10.251	49.97	10.789
8	70	48.8	60	60.07	6.895	60.10	7.553	59.95	7.764	59.95	8.503
8	70	48.8	70	69.63	6.032	69.79	8.720	69.92	6.685	69.92	9.899
8	70	48.8	80	79.13	6.264	79.47	8.107	79.88	6.904	79.89	9.548
8	70	48.8	90	88.73	6.997	89.05	8.412	89.84	8.046	89.84	9.956
10	80	57.6	40	40.51	8.924	40.56	9.713	39.98	10.390	39.98	11.662
10	80	57.6	50	50.20	7.438	50.35	6.941	49.96	8.657	49.96	9.072
10	80	57.6	60	59.73	5.966	59.78	6.474	59.94	6.654	59.94	7.194
10	80	57.6	70	69.18	5.287	69.42	7.358	69.91	5.802	69.91	8.342
10	80	57.6	80	78.57	5.384	79.05	6.839	79.85	5.823	79.86	8.014
10	80	57.6	90	88.05	6.063	88.55	7.089	89.75	6.790	89.79	8.120
10	100	77.6	40	40.23	6.659	40.30	7.150	39.97	7.677	39.97	8.516
10	100	77.6	50	49.67	5.588	49.88	5.346	49.95	6.375	49.95	6.632
10	100	77.6	60	58.99	4.582	59.10	4.898	59.92	4.992	59.93	5.320
10	100	77.6	70	68.15	4.122	68.60	5.426	69.74	4.419	69.88	6.157
10	100	77.6	80	77.39	4.109	78.11	5.024	79.62	4.298	79.81	5.865
10	100	77.6	90	86.61	4.508	87.48	5.269	89.43	5.010	89.59	5.952
10	120	97.6	40	39.86	5.384	39.96	5.717	39.96	6.055	39.96	6.638
10	120	97.6	50	49.05	4.515	49.27	4.407	49.95	5.061	49.96	5.240
10	120	97.6	60	58.05	3.796	58.20	4.010	59.91	3.992	59.96	4.215
10	120	97.6	70	67.07	3.449	67.52	4.337	69.56	3.594	69.81	4.869
10	120	97.6	80	76.04	3.370	76.92	4.008	79.22	3.436	79.60	4.625
10	120	97.6	90	85.19	3.630	86.22	4.218	88.90	3.938	89.26	4.687
10	140	117.6	40	39.43	4.539	39.53	4.777	39.98	4.993	39.97	5.417
10	140	117.6	50	48.31	3.840	48.59	3.791	50.02	4.160	50.04	4.171
10	140	117.6	60	57.13	3.272	57.29	3.426	59.75	3.350	59.86	3.493
10	140	117.6	70	65.92	2.991	66.48	3.652	69.28	3.041	69.66	4.025
10	140	117.6	80	74.71	2.905	75.70	3.366	78.71	2.878	79.32	3.808
10	140	117.6	90	83.63	3.060	84.91	3.533	88.15	3.254	88.78	3.872

Table 7D. Emissions of hydro carbons of diesel trains by alternatives

WAGONS #	GROSS MASS t	LOAD MASS t	LOAD DEG. %	TARGET SPEED km/h	AVG SPEED km/h	HC EMISSIONS g/trainkm	mg/gross tkm	mg/net tkm
6	327	84	23.3	40	40.15	5.383	16.462	64.083
6	327	84	23.3	50	50.02	6.525	19.954	77.680
6	327	84	23.3	60	59.01	3.183	9.734	37.893
6	327	84	23.3	70	68.33	4.438	13.573	52.837
6	327	84	23.3	80	77.69	5.211	15.937	62.040
6	327	84	23.3	90	84.83	4.869	14.889	57.962
11	547	154	23.3	40	39.91	4.292	7.847	27.871
11	547	154	23.3	50	48.44	5.135	9.388	33.345
11	547	154	23.3	60	55.49	2.129	3.893	13.826
11	547	154	23.3	70	61.55	2.878	5.261	18.688
11	547	154	23.3	80	65.77	3.431	6.272	22.279
11	547	154	23.3	90	67.33	3.383	6.184	21.966
9	603	270	50.0	40	39.61	4.147	6.877	15.359
9	603	270	50.0	50	47.87	4.920	8.159	18.222
9	603	270	50.0	60	54.60	2.117	3.511	7.840
9	603	270	50.0	70	60.16	2.769	4.591	10.254
9	603	270	50.0	80	64.12	3.356	5.566	12.430
9	603	270	50.0	90	65.35	3.303	5.477	12.233
12	663	240	33.3	40	39.18	3.846	5.802	16.027
12	663	240	33.3	50	46.98	4.609	6.952	19.204
12	663	240	33.3	60	52.91	2.266	3.419	9.444
12	663	240	33.3	70	56.84	2.511	3.788	10.463
12	663	240	33.3	80	59.29	2.899	4.373	12.080
12	663	240	33.3	90	60.13	2.974	4.486	12.393
9	693	360	66.7	40	39.12	3.858	5.567	10.717
9	693	360	66.7	50	46.84	4.634	6.687	12.872
9	693	360	66.7	60	52.72	2.256	3.256	6.268
9	693	360	66.7	70	56.81	2.537	3.661	7.047
9	693	360	66.7	80	59.54	2.985	4.308	8.293
9	693	360	66.7	90	60.44	3.016	4.352	8.378
8	783	480	100.0	40	38.59	3.756	4.797	7.825
8	783	480	100.0	50	45.97	4.462	5.698	9.295
8	783	480	100.0	60	51.28	2.579	3.293	5.372
8	783	480	100.0	70	54.50	2.692	3.438	5.609
8	783	480	100.0	80	56.21	2.919	3.728	6.082
8	783	480	100.0	90	56.90	2.994	3.824	6.238

Table 8A. Emissions of particulate matters of trucks by alternatives
Rated engine power 250 kW

RATED ENGINE POWER 250 kW				POLLUTANT EMISSIONS OF PARTICULATE MATTERS							
PROFILE				ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO				3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD MASS	TARGET SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.41	4.646	40.45	4.710	39.98	5.052	39.98	5.245
7	50	31.7	50	49.90	4.144	50.08	3.717	49.97	4.488	49.97	4.497
7	50	31.7	60	59.24	3.687	59.30	3.761	59.95	3.937	59.95	4.023
7	50	31.7	70	68.33	3.449	68.78	3.621	69.78	3.704	69.91	4.066
7	50	31.7	80	77.33	3.585	78.20	3.635	79.64	3.817	79.86	4.386
7	50	31.7	90	86.27	3.332	87.33	4.210	89.38	3.418	89.60	5.042
7	60	41.7	40	40.09	3.681	40.17	3.708	39.98	3.973	39.98	4.100
7	60	41.7	50	49.37	3.292	49.57	3.033	49.96	3.537	49.96	3.531
7	60	41.7	60	58.44	2.957	58.57	2.993	59.92	3.135	59.94	3.183
7	60	41.7	70	67.32	2.760	67.86	2.828	69.53	2.955	69.89	3.080
7	60	41.7	80	76.02	2.852	77.11	2.764	79.13	2.997	79.67	3.200
7	60	41.7	90	84.79	2.638	86.09	3.166	88.69	2.685	89.22	3.771
8	70	48.8	40	39.67	3.310	39.78	3.317	39.97	3.528	39.97	3.617
8	70	48.8	50	48.67	2.968	48.93	2.748	49.96	3.146	49.96	3.127
8	70	48.8	60	57.42	2.678	57.58	2.713	59.70	2.828	59.82	2.853
8	70	48.8	70	66.09	2.510	66.71	2.515	69.16	2.647	69.69	2.648
8	70	48.8	80	74.45	2.572	75.71	2.410	78.39	2.676	79.35	2.673
8	70	48.8	90	82.88	2.388	84.54	2.717	87.45	2.399	88.57	3.165
10	80	57.6	40	39.15	2.965	39.28	2.957	39.97	3.128	39.97	3.185
10	80	57.6	50	47.79	2.676	48.13	2.494	49.92	2.801	49.96	2.769
10	80	57.6	60	56.35	2.419	56.52	2.435	59.44	2.530	59.56	2.550
10	80	57.6	70	64.64	2.278	65.42	2.235	68.69	2.356	69.34	2.288
10	80	57.6	80	72.58	2.314	74.22	2.097	77.22	2.378	78.78	2.231
10	80	57.6	90	80.55	2.159	82.56	2.346	85.60	2.127	87.52	2.599
10	100	77.6	40	38.05	2.377	38.21	2.355	40.02	2.459	40.04	2.473
10	100	77.6	50	46.21	2.153	46.57	2.021	49.59	2.212	49.73	2.146
10	100	77.6	60	54.23	1.965	54.42	1.976	58.79	1.989	58.93	2.006
10	100	77.6	70	62.24	1.853	62.83	1.798	67.46	1.860	68.30	1.767
10	100	77.6	80	69.68	1.842	71.19	1.661	75.23	1.861	77.15	1.667
10	100	77.6	90	76.42	1.766	78.93	1.802	81.76	1.716	84.97	1.883
10	120	97.6	40	36.81	2.021	37.01	2.005	39.87	2.035	39.93	2.042
10	120	97.6	50	44.51	1.842	44.86	1.743	49.19	1.832	49.38	1.773
10	120	97.6	60	52.10	1.696	52.33	1.698	57.92	1.665	58.06	1.680
10	120	97.6	70	59.59	1.594	60.24	1.547	65.91	1.563	66.81	1.476
10	120	97.6	80	66.44	1.584	68.13	1.420	72.48	1.565	74.99	1.367
10	120	97.6	90	72.35	1.504	75.35	1.490	77.71	1.468	81.50	1.502
10	140	117.6	40	35.48	1.805	35.74	1.785	39.62	1.746	39.67	1.748
10	140	117.6	50	42.75	1.644	43.20	1.563	48.58	1.574	48.83	1.522
10	140	117.6	60	50.01	1.509	50.34	1.509	56.78	1.441	56.97	1.455
10	140	117.6	70	57.06	1.422	57.79	1.381	64.16	1.346	65.07	1.288
10	140	117.6	80	63.12	1.402	65.09	1.270	69.22	1.366	72.22	1.188
10	140	117.6	90	68.17	1.345	71.40	1.300	73.38	1.311	77.47	1.277

Table 8B. Emissions of particulate matters of trucks by alternatives
Rated engine power 346 kW

RATED ENGINE POWER 346 kW — POLLUTANT EMISSIONS OF PARTICULATE MATTERS

PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU			
FINAL GEAR RATIO			3.08		3.96		3.08		3.96	
AXLES	GROSS MASS	LOAD TARGET SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.53	3.656	40.56	1.572	39.98	3.848	39.98	.311
7	50	31.7	50	50.37	2.642	50.49	2.223	49.97	2.439	49.97	1.247
7	50	31.7	60	60.03	3.447	60.06	2.503	59.95	3.932	59.95	2.410
7	50	31.7	70	69.55	2.751	69.74	2.422	69.93	2.752	69.93	1.915
7	50	31.7	80	78.99	2.320	79.38	2.915	79.91	2.319	79.91	2.642
7	50	31.7	90	88.50	2.311	88.91	2.719	89.84	2.099	89.85	2.769
7	60	41.7	40	40.48	2.835	40.53	1.436	39.98	3.016	39.98	.592
7	60	41.7	50	50.16	2.121	50.31	1.792	49.96	1.994	49.96	1.177
7	60	41.7	60	59.64	2.595	59.70	2.006	59.94	2.895	59.94	1.915
7	60	41.7	70	69.01	2.152	69.30	2.002	69.91	2.117	69.92	1.598
7	60	41.7	80	78.31	1.903	78.86	2.299	79.85	1.987	79.87	2.163
7	60	41.7	90	87.64	1.844	88.26	2.149	89.70	1.674	89.79	2.220
8	70	48.8	40	40.32	2.491	40.39	1.439	39.97	2.605	39.97	.739
8	70	48.8	50	49.80	1.923	50.00	1.658	49.96	1.788	49.96	1.203
8	70	48.8	60	59.15	2.230	59.24	1.805	59.93	2.430	59.93	1.759
8	70	48.8	70	68.29	1.927	68.72	1.830	69.76	1.902	69.90	1.476
8	70	48.8	80	77.44	1.733	78.19	2.032	79.65	1.816	79.83	1.942
8	70	48.8	90	86.53	1.678	87.45	1.914	89.43	1.507	89.61	1.985
10	80	57.6	40	40.05	2.181	40.12	1.389	39.97	2.255	39.97	.856
10	80	57.6	50	49.35	1.735	49.54	1.507	49.95	1.632	49.95	1.175
10	80	57.6	60	58.46	1.937	58.57	1.598	59.92	2.045	59.92	1.590
10	80	57.6	70	67.43	1.720	67.92	1.694	69.56	1.702	69.87	1.366
10	80	57.6	80	76.35	1.564	77.25	1.786	79.30	1.647	79.68	1.725
10	80	57.6	90	85.33	1.504	86.42	1.685	88.95	1.341	89.33	1.712
10	100	77.6	40	39.43	1.712	39.50	1.244	39.96	1.715	39.97	.839
10	100	77.6	50	48.33	1.389	48.54	1.257	49.95	1.336	49.95	1.058
10	100	77.6	60	57.05	1.533	57.20	1.419	59.65	1.564	59.77	1.366
10	100	77.6	70	65.70	1.380	66.31	1.376	69.11	1.378	69.58	1.106
10	100	77.6	80	74.24	1.250	75.38	1.408	78.35	1.248	79.23	1.362
10	100	77.6	90	82.82	1.213	84.33	1.322	87.53	1.086	88.53	1.330
10	120	97.6	40	38.64	1.440	38.77	1.128	40.01	1.400	40.00	.838
10	120	97.6	50	47.15	1.281	47.44	1.096	49.85	1.207	49.95	.963
10	120	97.6	60	55.59	1.283	55.75	1.210	59.33	1.280	59.47	1.162
10	120	97.6	70	63.98	1.171	64.55	1.168	68.54	1.158	69.11	.936
10	120	97.6	80	72.02	1.066	73.46	1.176	77.10	1.027	78.50	1.128
10	120	97.6	90	80.30	1.034	81.98	1.104	85.63	.934	87.35	1.097
10	140	117.6	40	37.74	1.260	37.99	1.026	40.06	1.192	40.10	.802
10	140	117.6	50	45.92	1.165	46.32	1.088	49.64	1.080	49.81	.951
10	140	117.6	60	54.04	1.120	54.30	1.066	58.89	1.093	59.04	1.006
10	140	117.6	70	62.23	1.030	62.85	1.030	67.71	1.019	68.44	.829
10	140	117.6	80	70.08	.931	71.49	1.018	75.90	.881	77.49	.967
10	140	117.6	90	77.69	.915	79.72	.961	83.41	.836	85.85	.939

Table 8C. Emissions of particulate matters of trucks by alternatives
Rated engine power 456 kW

RATED ENGINE POWER 456 kW				POLLUTANT EMISSIONS OF PARTICULATE MATTERS							
PROFILE			ROAD PROFILE HELSINKI-OULU				RAIL PROFILE HELSINKI-OULU				
FINAL GEAR RATIO			3.08		3.96		3.08		3.96		
AXLES	GROSS MASS	LOAD MASS	TARGET AVG SPEED	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.	AVG SPEED	AVG EMIS.
#	t	t	km/h	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm	km/h	mg/tkm
7	50	31.7	40	40.51	4.722	40.53	1.387	39.98	5.401	39.98	.431
7	50	31.7	50	50.51	3.171	50.60	2.812	49.98	2.899	49.97	1.082
7	50	31.7	60	60.41	4.686	60.38	3.018	59.96	5.682	59.96	2.923
7	50	31.7	70	70.17	3.545	70.18	2.705	69.94	3.910	69.95	2.023
7	50	31.7	80	79.85	1.960	79.95	3.576	79.93	1.399	79.93	3.027
7	50	31.7	90	89.58	2.564	89.67	3.215	89.89	2.265	89.89	3.242
7	60	41.7	40	40.58	3.621	40.59	1.313	39.98	3.972	39.98	.321
7	60	41.7	50	50.49	2.524	50.62	2.141	49.97	2.356	49.97	.993
7	60	41.7	60	60.31	3.468	60.30	2.383	59.95	4.149	59.96	2.302
7	60	41.7	70	69.94	2.700	70.04	2.250	69.93	2.872	69.94	1.663
7	60	41.7	80	79.56	1.660	79.75	2.823	79.90	1.440	79.91	2.528
7	60	41.7	90	89.24	2.067	89.42	2.537	89.87	1.844	89.87	2.585
8	70	48.8	40	40.58	3.140	40.60	1.389	39.98	3.345	39.98	.272
8	70	48.8	50	50.41	2.264	50.52	1.885	49.97	2.105	49.97	1.084
8	70	48.8	60	60.07	2.941	60.10	2.126	59.95	3.434	59.95	2.070
8	70	48.8	70	69.63	2.339	69.79	2.078	69.92	2.405	69.92	1.572
8	70	48.8	80	79.13	1.534	79.47	2.487	79.88	1.494	79.89	2.299
8	70	48.8	90	88.73	1.949	89.05	2.250	89.84	1.712	89.84	2.303
10	80	57.6	40	40.51	2.723	40.56	1.371	39.98	2.902	39.98	.553
10	80	57.6	50	50.20	2.023	50.35	1.708	49.96	1.897	49.96	1.102
10	80	57.6	60	59.73	2.486	59.78	1.898	59.94	2.817	59.94	1.813
10	80	57.6	70	69.18	2.038	69.42	1.896	69.91	2.039	69.91	1.458
10	80	57.6	80	78.57	1.723	79.05	2.170	79.85	1.664	79.86	2.039
10	80	57.6	90	88.05	1.735	88.55	1.981	89.75	1.521	89.79	1.987
10	100	77.6	40	40.23	2.097	40.30	1.256	39.97	2.196	39.97	.684
10	100	77.6	50	49.67	1.626	49.88	1.408	49.95	1.505	49.95	1.024
10	100	77.6	60	58.99	1.857	59.10	1.510	59.92	2.022	59.93	1.455
10	100	77.6	70	68.15	1.593	68.60	1.551	69.74	1.591	69.88	1.210
10	100	77.6	80	77.39	1.405	78.11	1.689	79.62	1.402	79.81	1.616
10	100	77.6	90	86.61	1.379	87.48	1.555	89.43	1.200	89.59	1.555
10	120	97.6	40	39.86	1.723	39.96	1.149	39.96	1.768	39.96	.744
10	120	97.6	50	49.05	1.375	49.27	1.214	49.95	1.288	49.96	.935
10	120	97.6	60	58.05	1.514	58.20	1.265	59.91	1.585	59.96	1.221
10	120	97.6	70	67.07	1.332	67.52	1.327	69.56	1.329	69.81	1.039
10	120	97.6	80	76.04	1.199	76.92	1.402	79.22	1.171	79.60	1.348
10	120	97.6	90	85.19	1.165	86.22	1.293	88.90	1.018	89.26	1.288
10	140	117.6	40	39.43	1.487	39.53	1.078	39.98	1.466	39.97	.714
10	140	117.6	50	48.31	1.209	48.59	1.084	50.02	1.112	50.04	.904
10	140	117.6	60	57.13	1.306	57.29	1.144	59.75	1.345	59.86	1.092
10	140	117.6	70	65.92	1.166	66.48	1.202	69.28	1.160	69.66	.939
10	140	117.6	80	74.71	1.046	75.70	1.207	78.71	1.036	79.32	1.166
10	140	117.6	90	83.63	1.021	84.91	1.110	88.15	.897	88.78	1.105

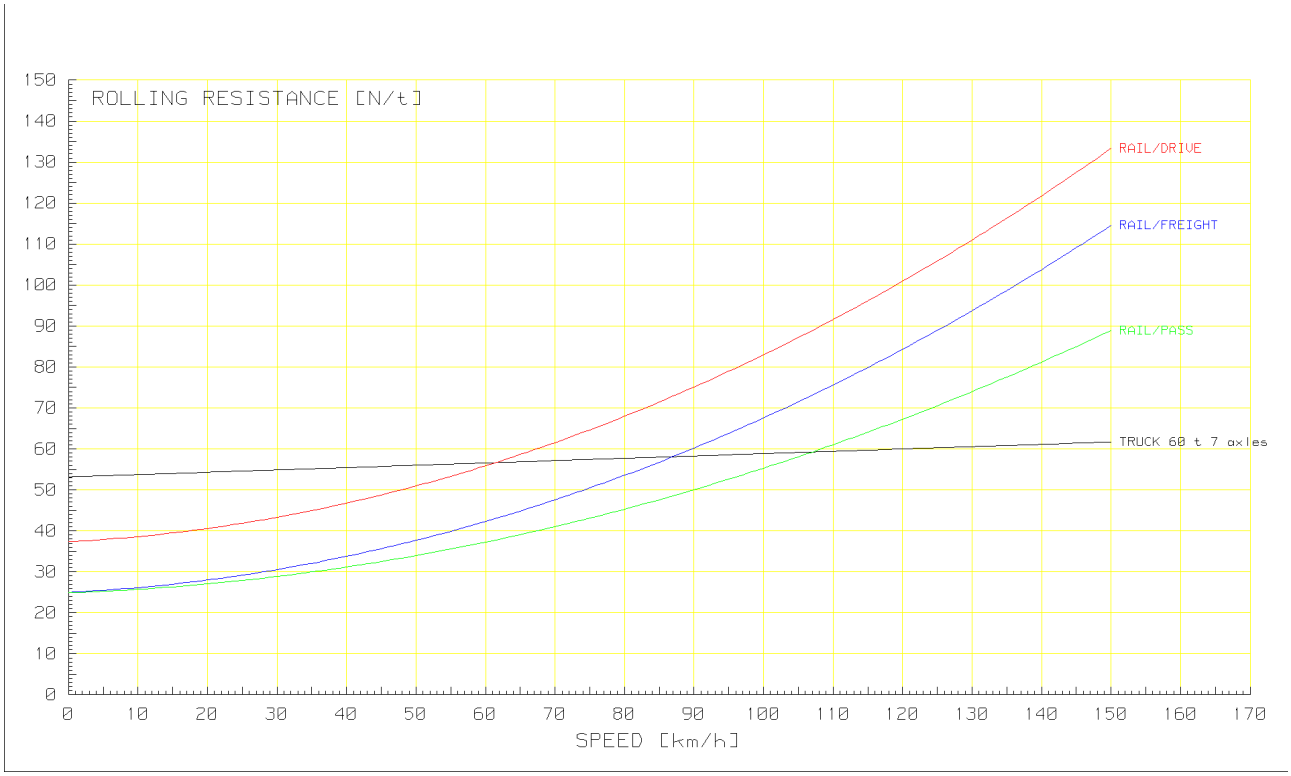

Fig. 1 Rolling resistance coefficient vs. speed by transportation modes

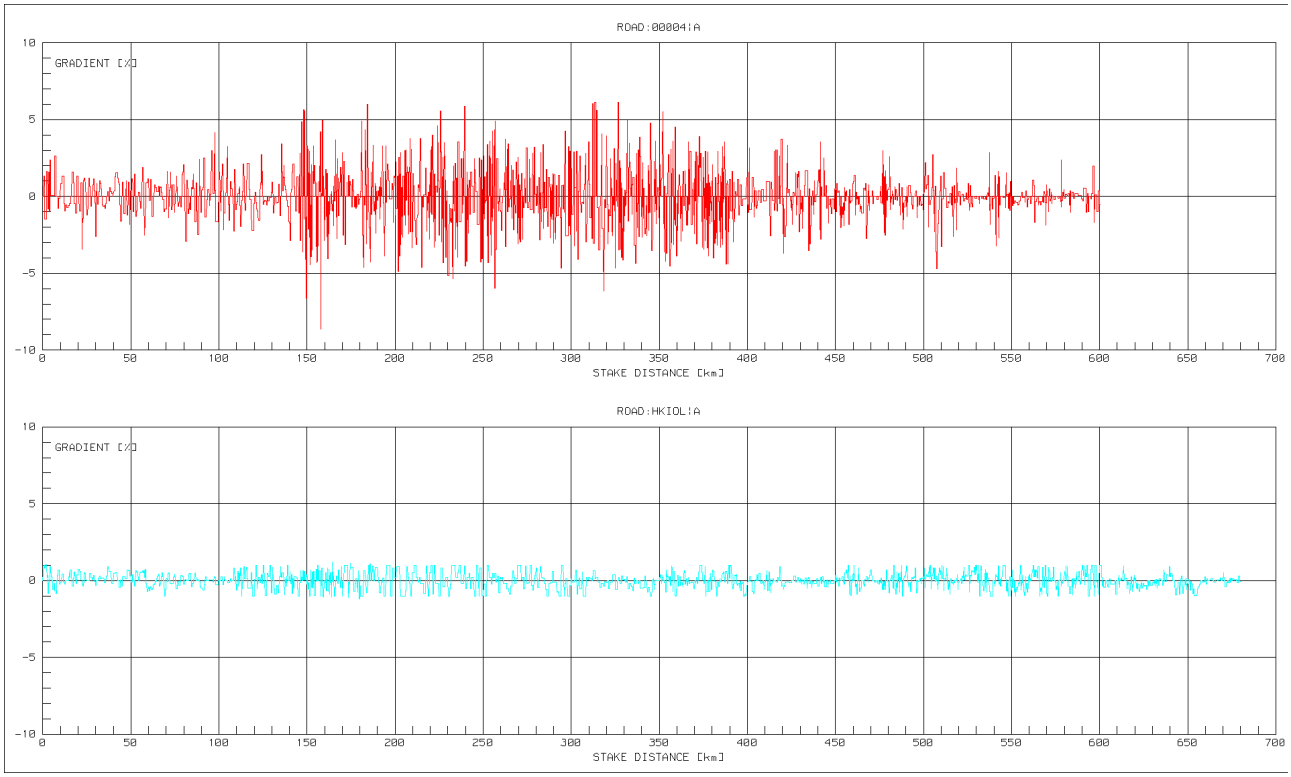

Fig. 2 Vertical alignment of road and railway between Helsinki and Oulu. 00004|A is the road and HKIOL|A is the railway between Helsinki and Oulu

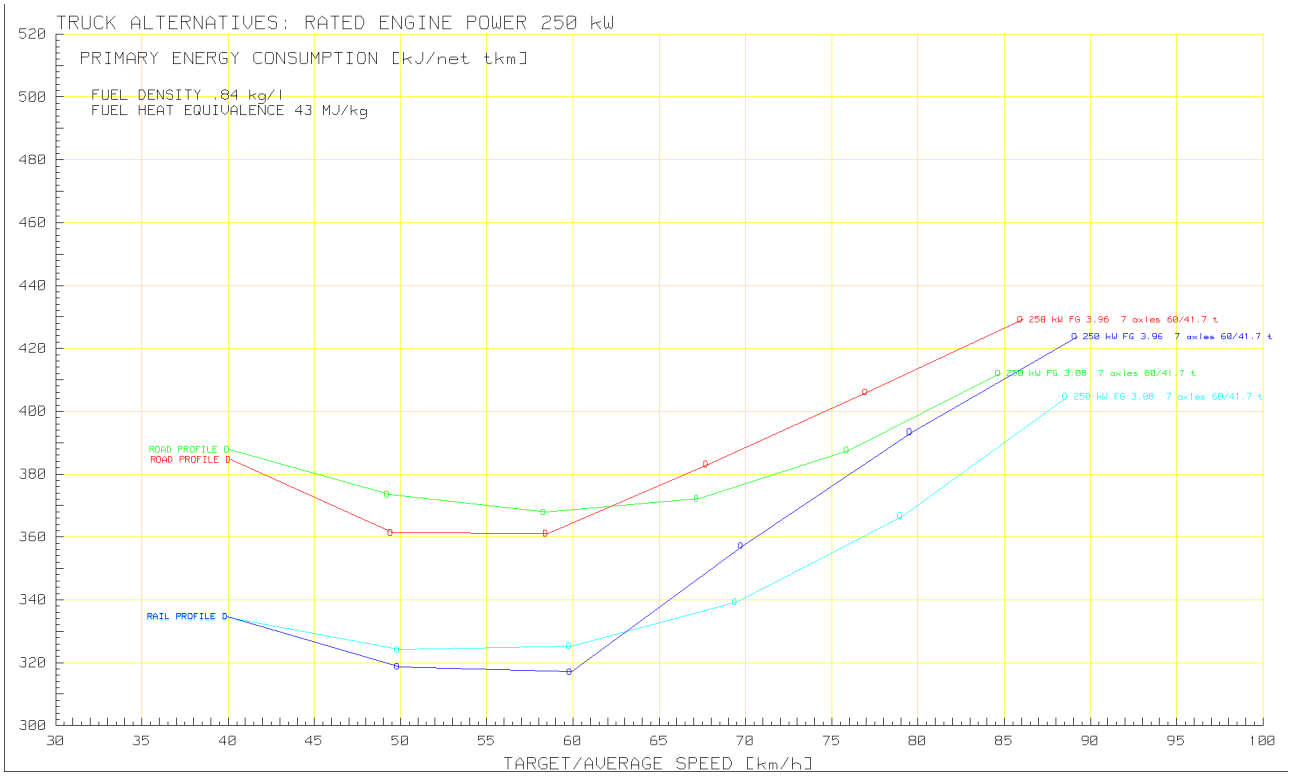

Fig. 3A Primary energy use and average speed vs. final gear ratio and route profile. Rated engine power 250 kW

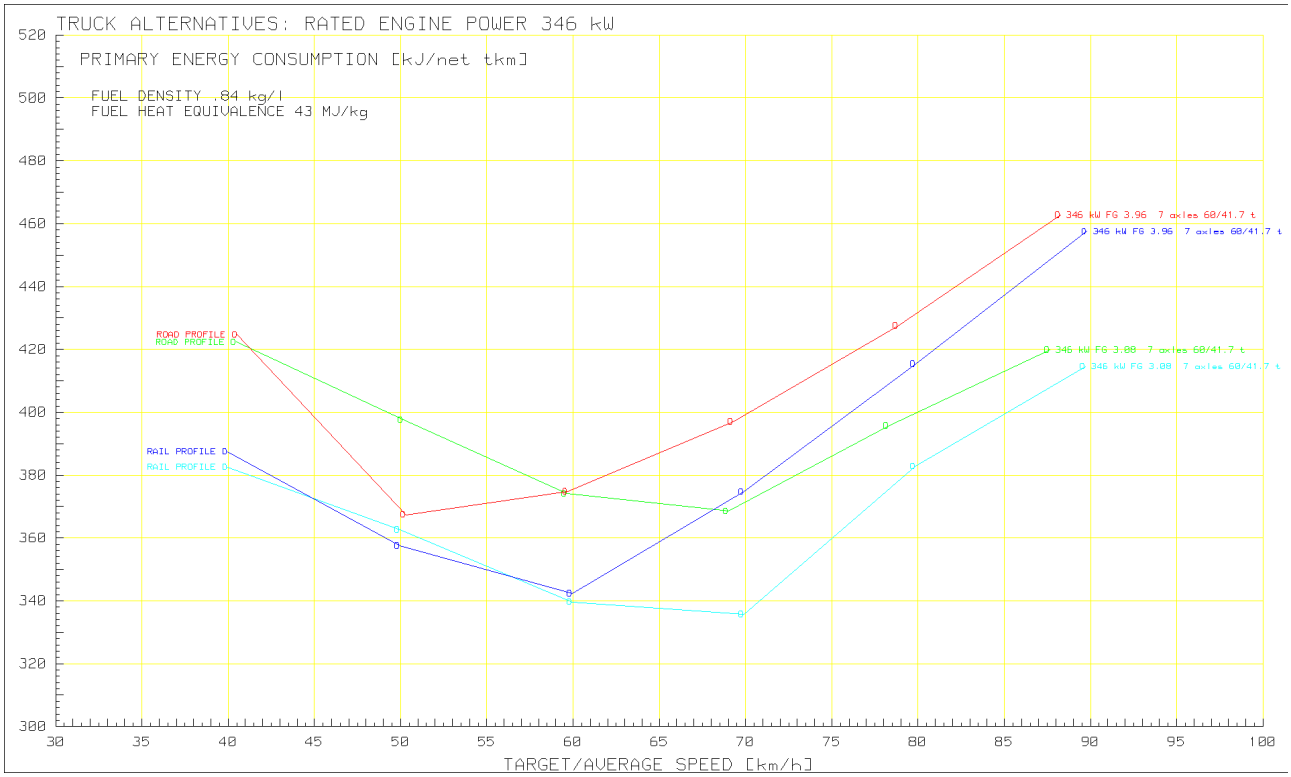

Fig. 3B Primary energy use and average speed vs. final gear ratio and route profile. Rated engine power 346 kW

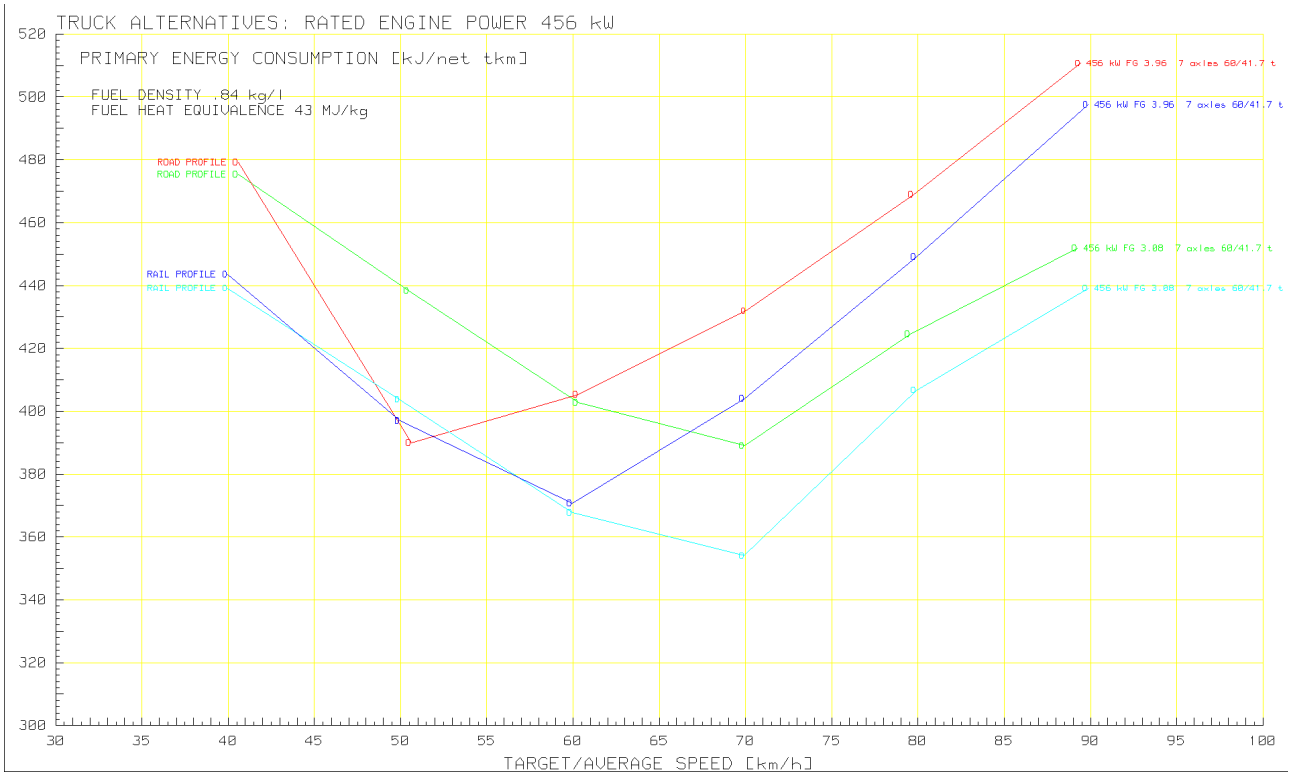

Fig. 3C Primary energy use and average speed vs. final gear ratio and route profile. Rated engine power 456 kW

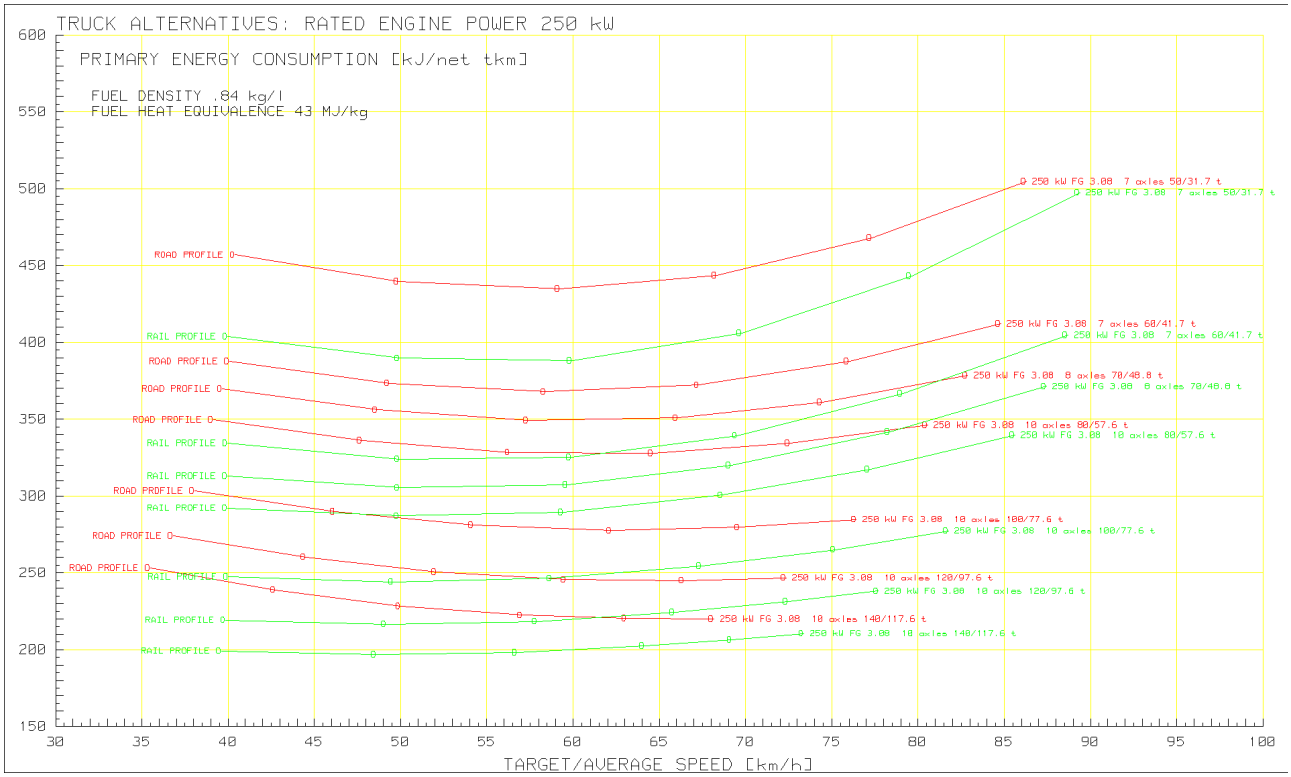

Fig. 4A Primary energy use and average speed vs. gross mass and route profile. Rated engine power 250 kW

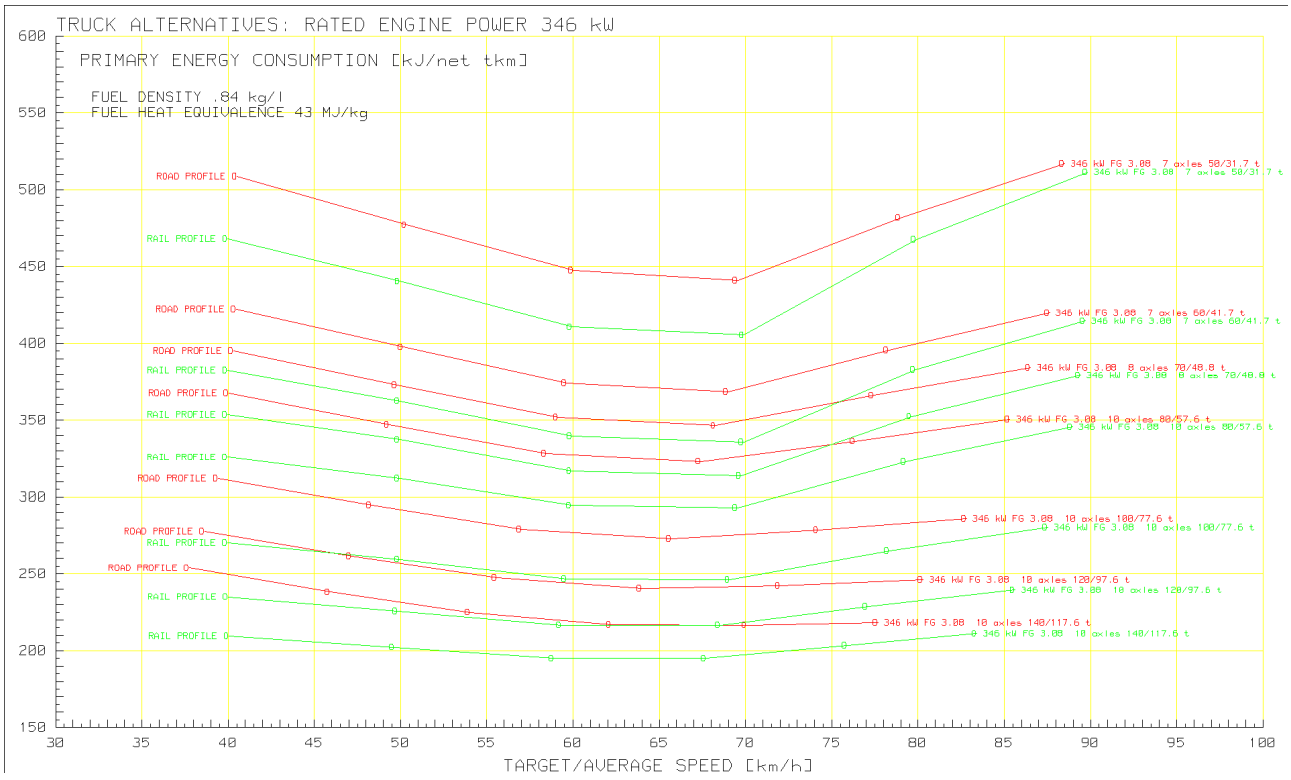

Fig. 4B Primary energy use and average speed vs. gross mass and route profile. Rated engine power 346 kW

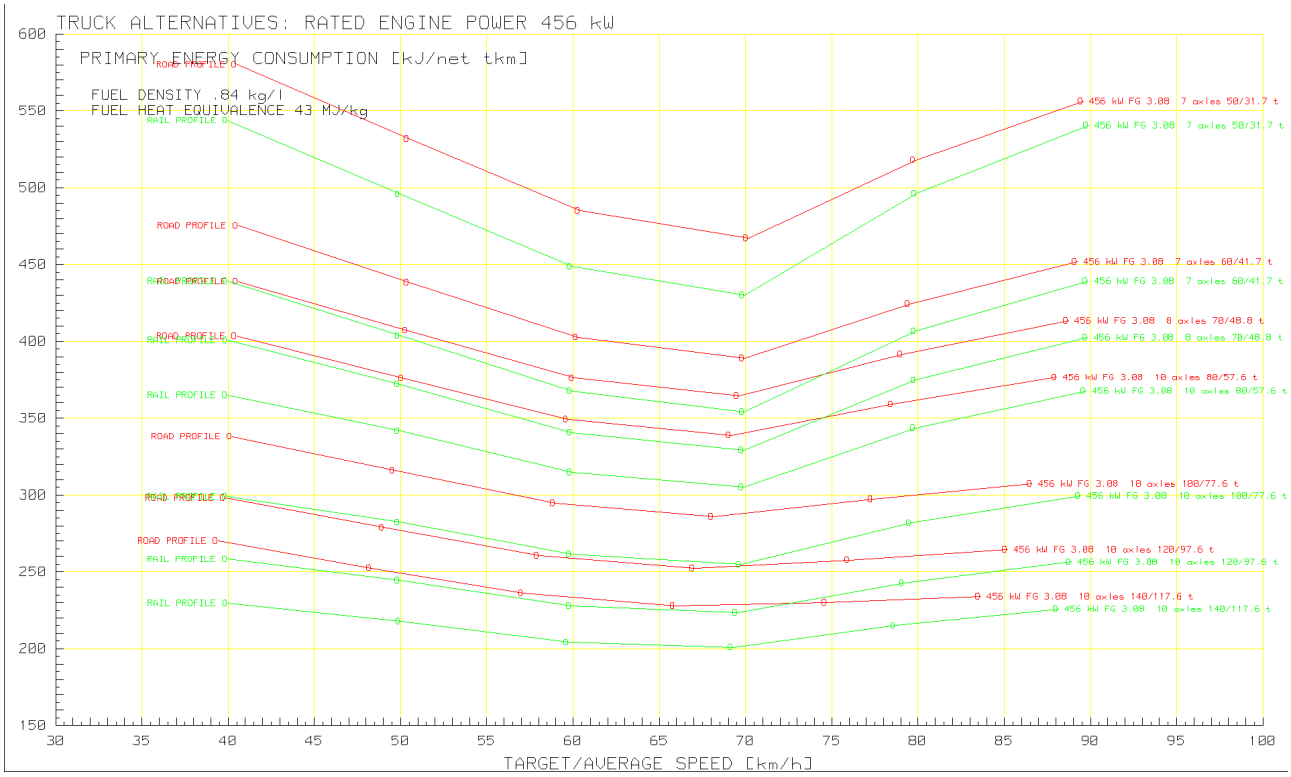

Fig. 4C Primary energy use and average speed vs. gross mass and route profile. Rated engine power 456 kW

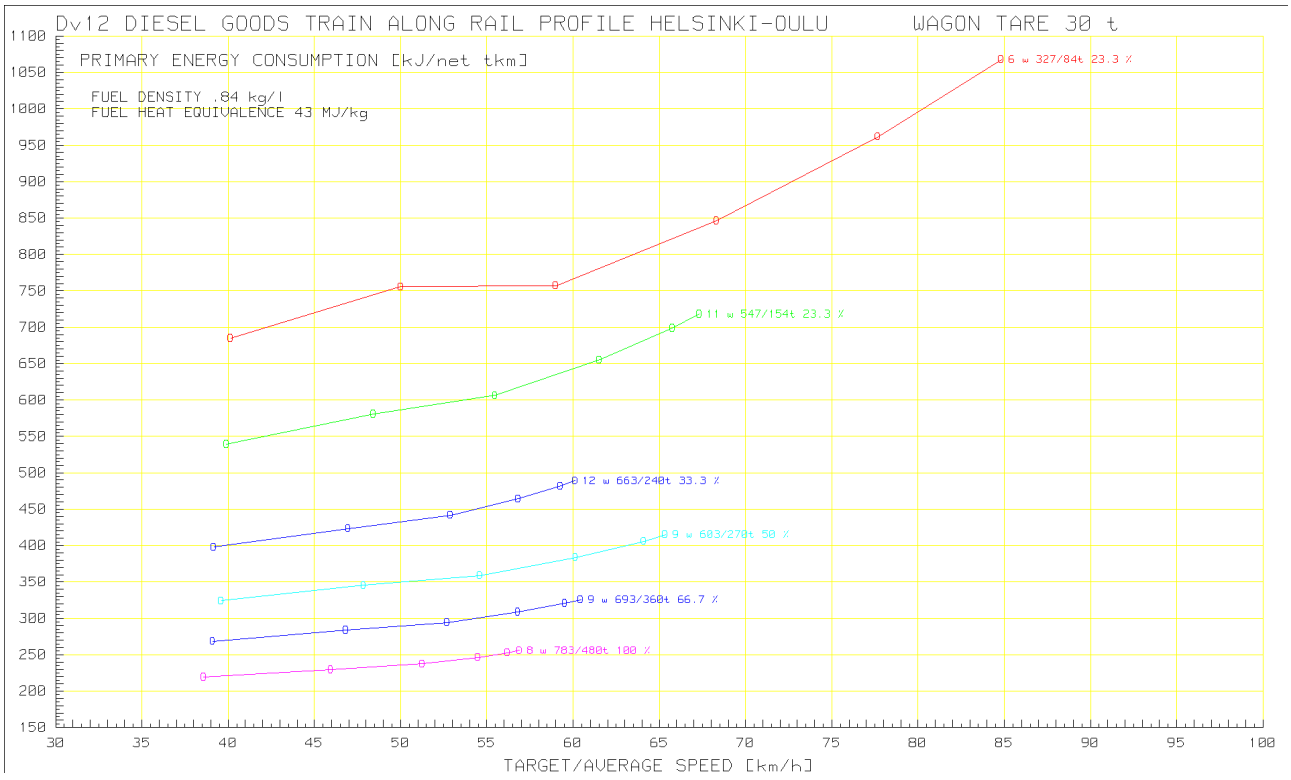

Fig. 5 Primary energy use and average speed of diesel train vs. mass and number of wagons

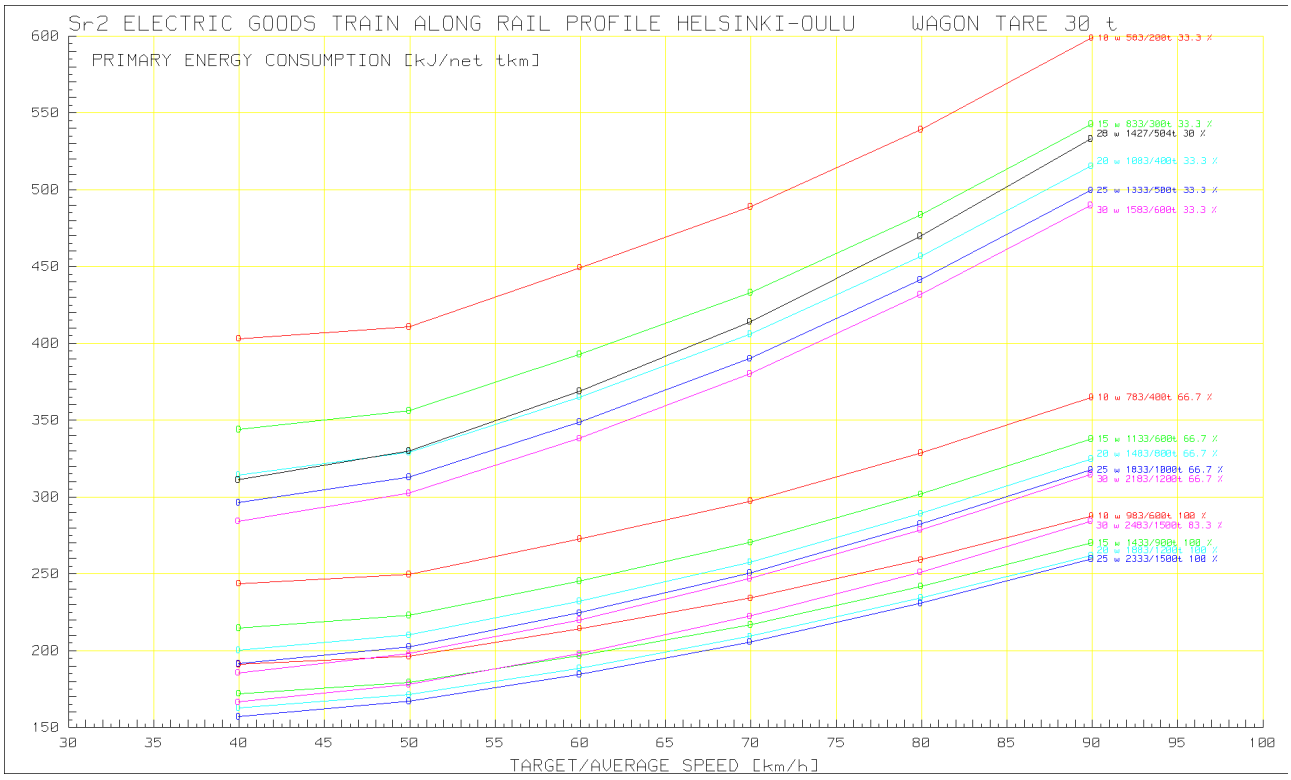

Fig. 6 Primary energy use and average speed of electric train vs. mass and number of wagons

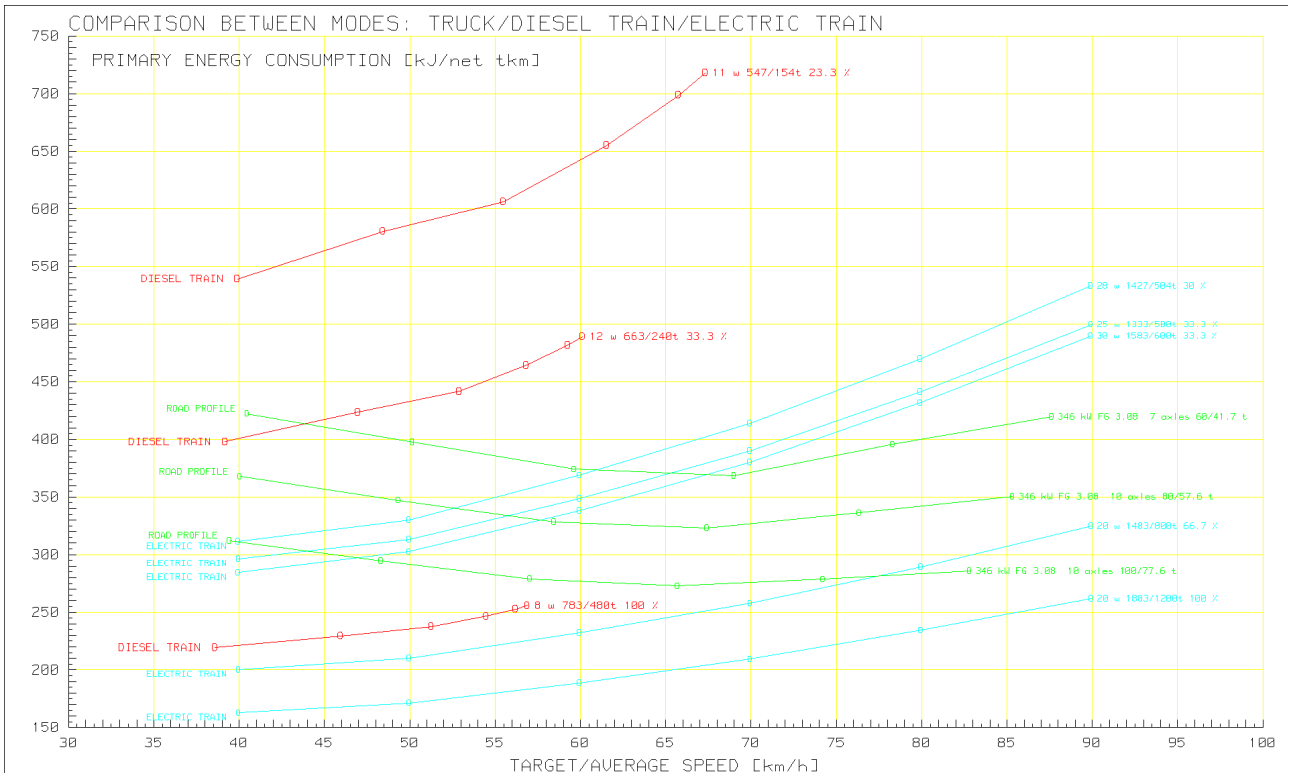

Fig. 7A Comparison between truck and trains. Truck route is road profile

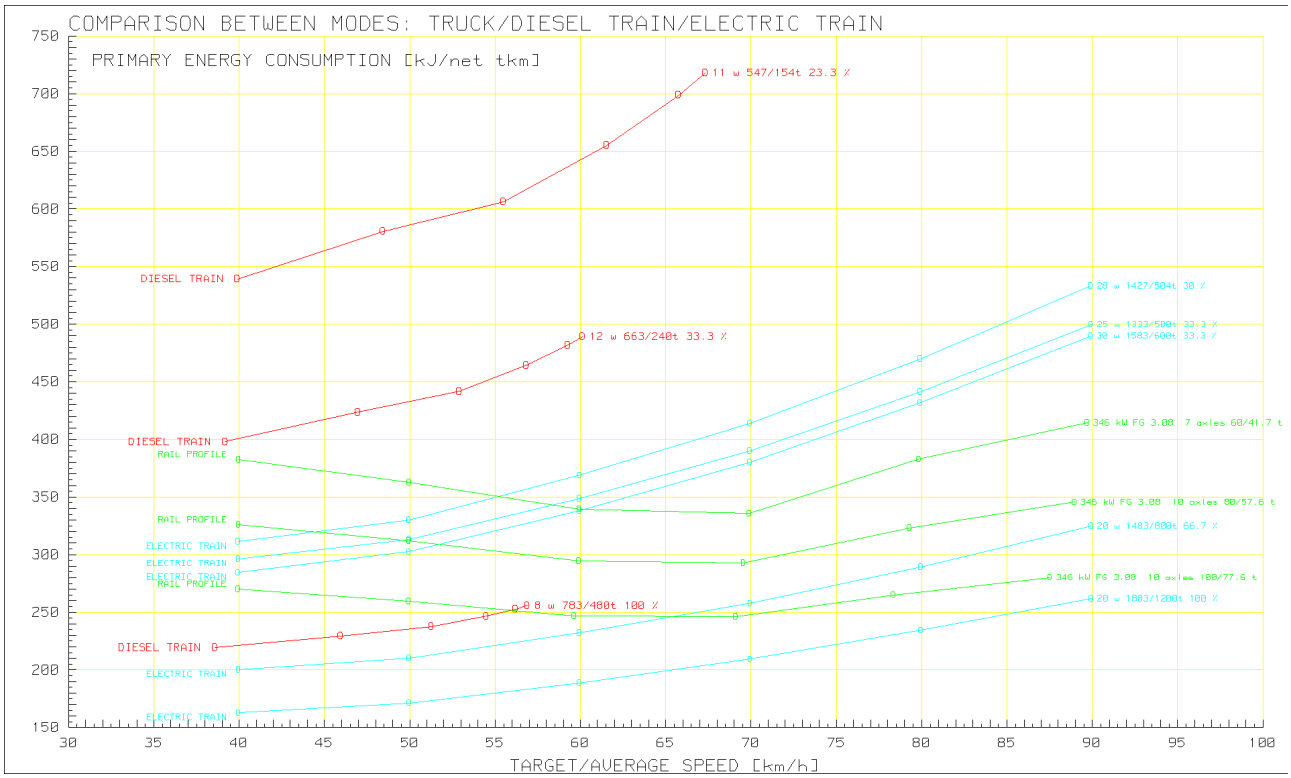

Fig. 7B Comparison between truck and trains. Truck route is rail profile

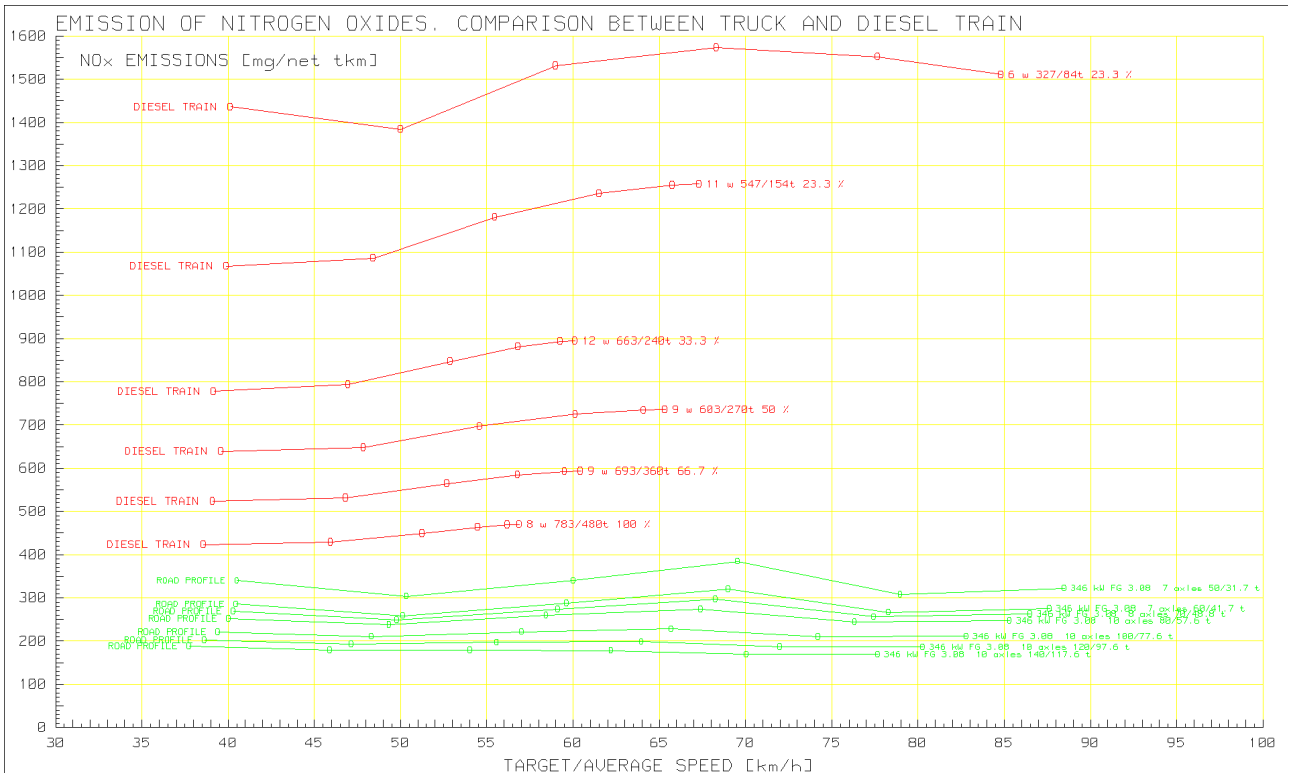

Fig. 8 Emissions of nitrogen oxides: comparison between truck and diesel train

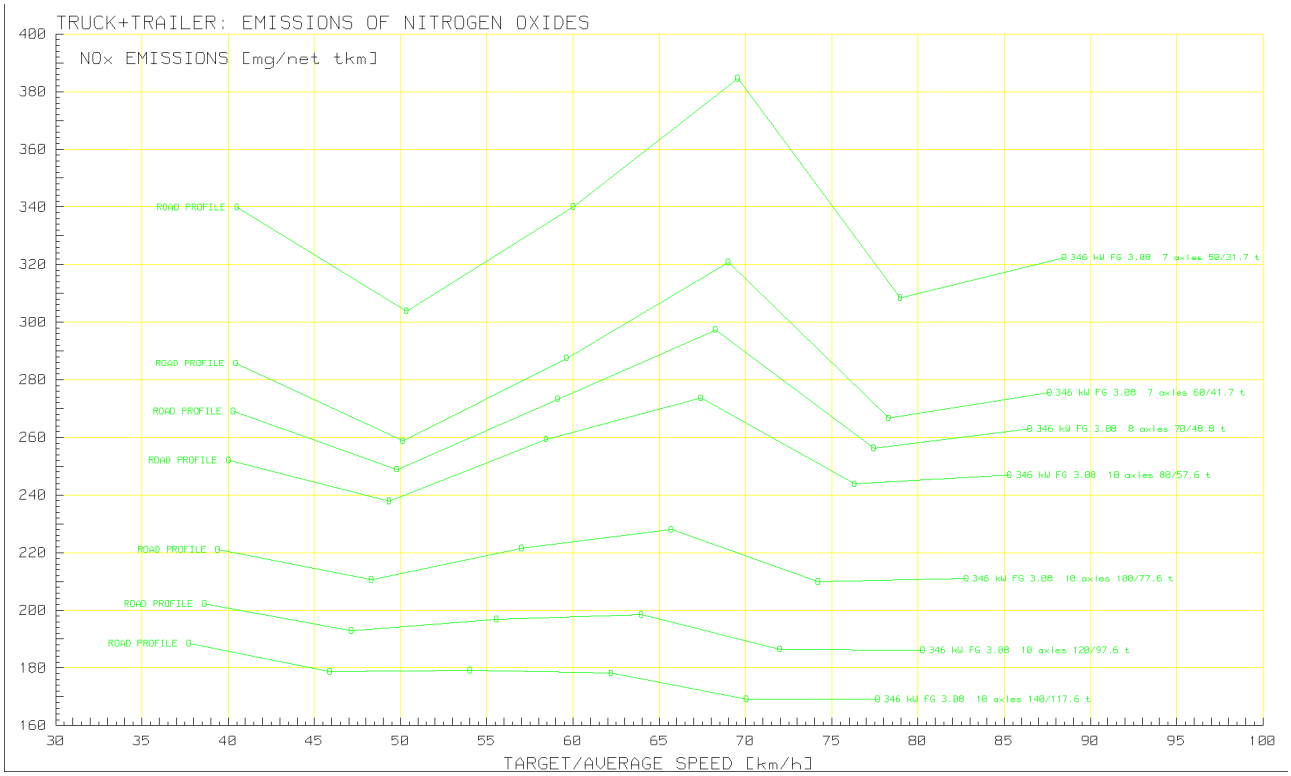

Fig. 8A Emissions of nitrogen oxides of truck on road profile

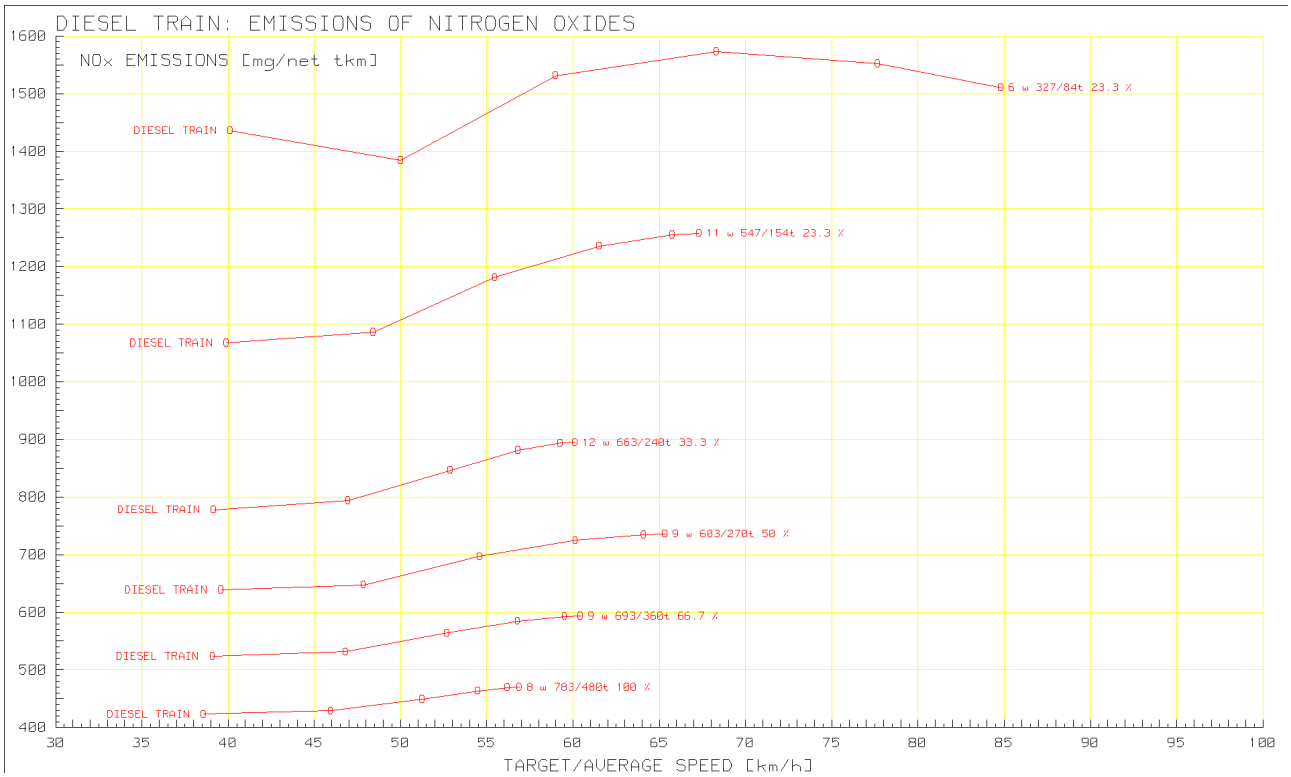

Fig. 8B Emissions of nitrogen oxides of diesel trains

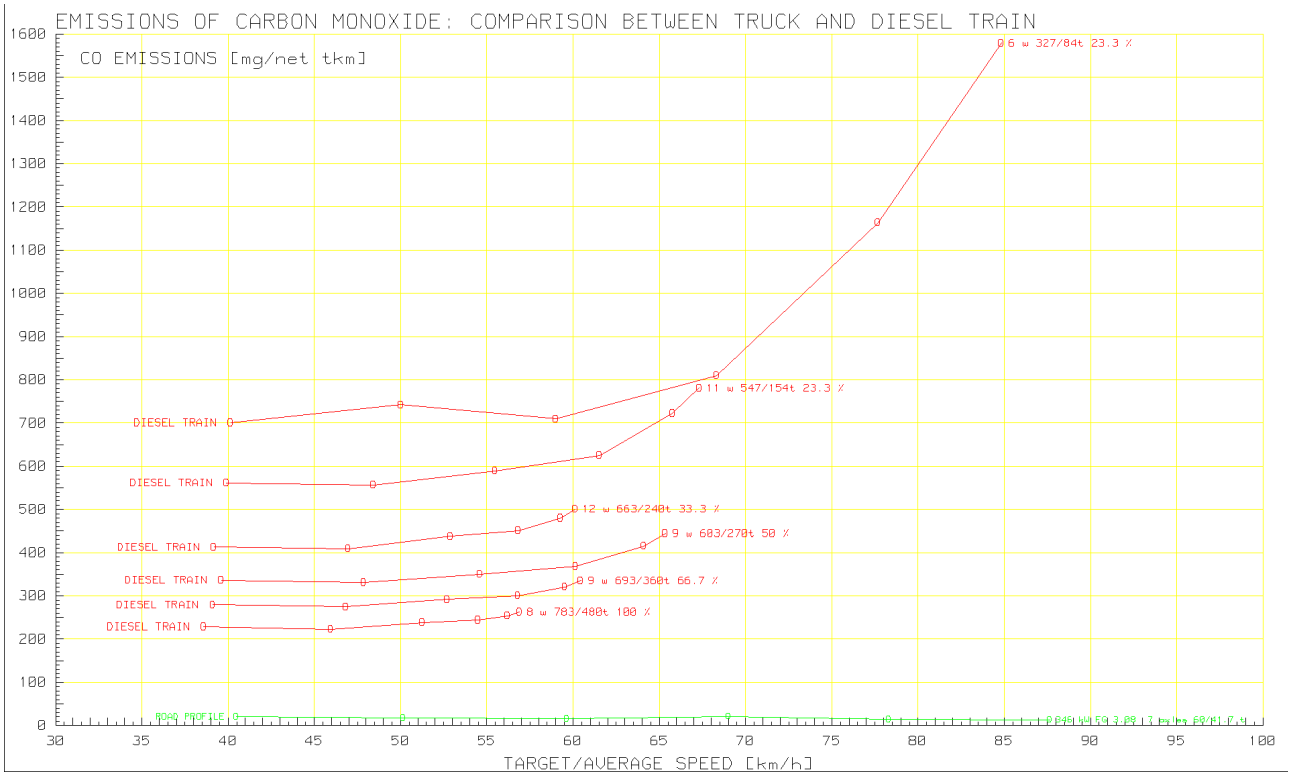

Fig. 9 Emissions of carbon monoxide: comparison between truck and diesel train

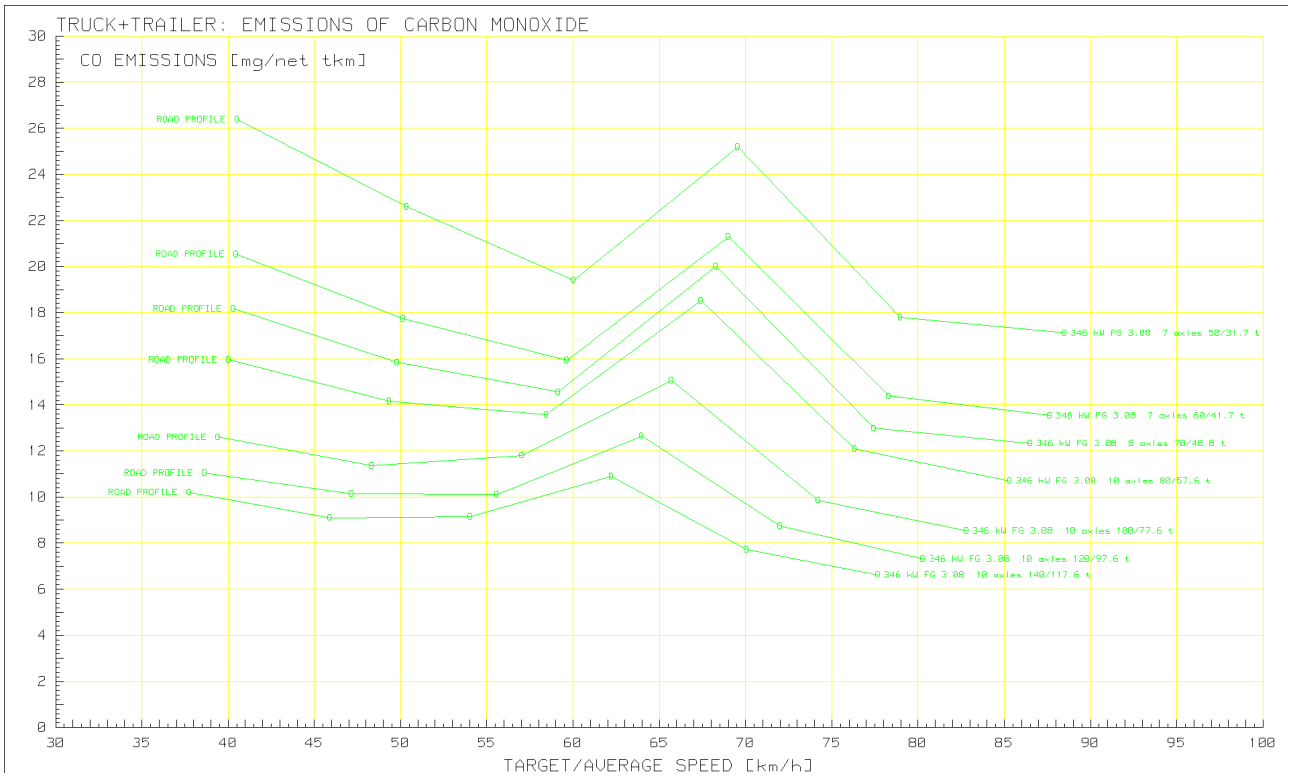

Fig. 9A Emissions of carbon monoxide of truck on road profile

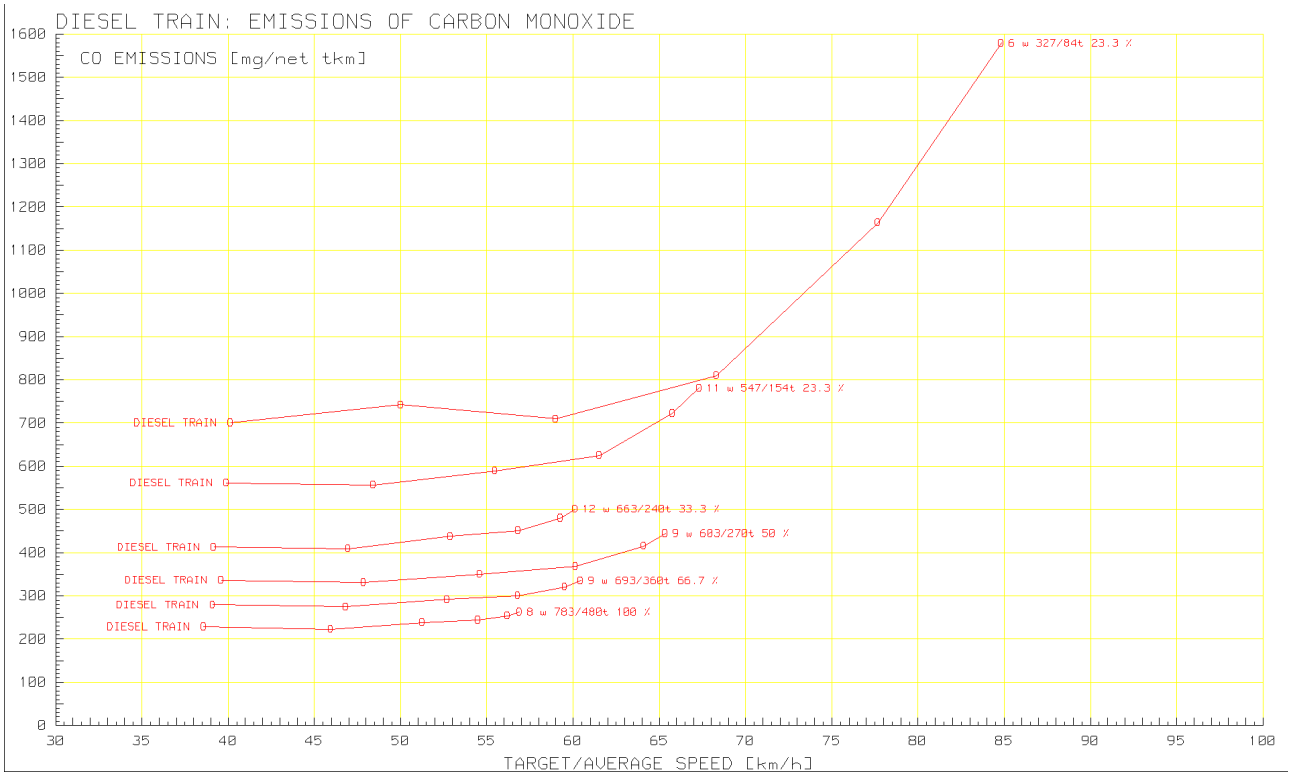

Fig. 9B Emissions of carbon monoxide of diesel train

Fig. 10 Emissions of hydro carbons: comparison between truck and diesel train

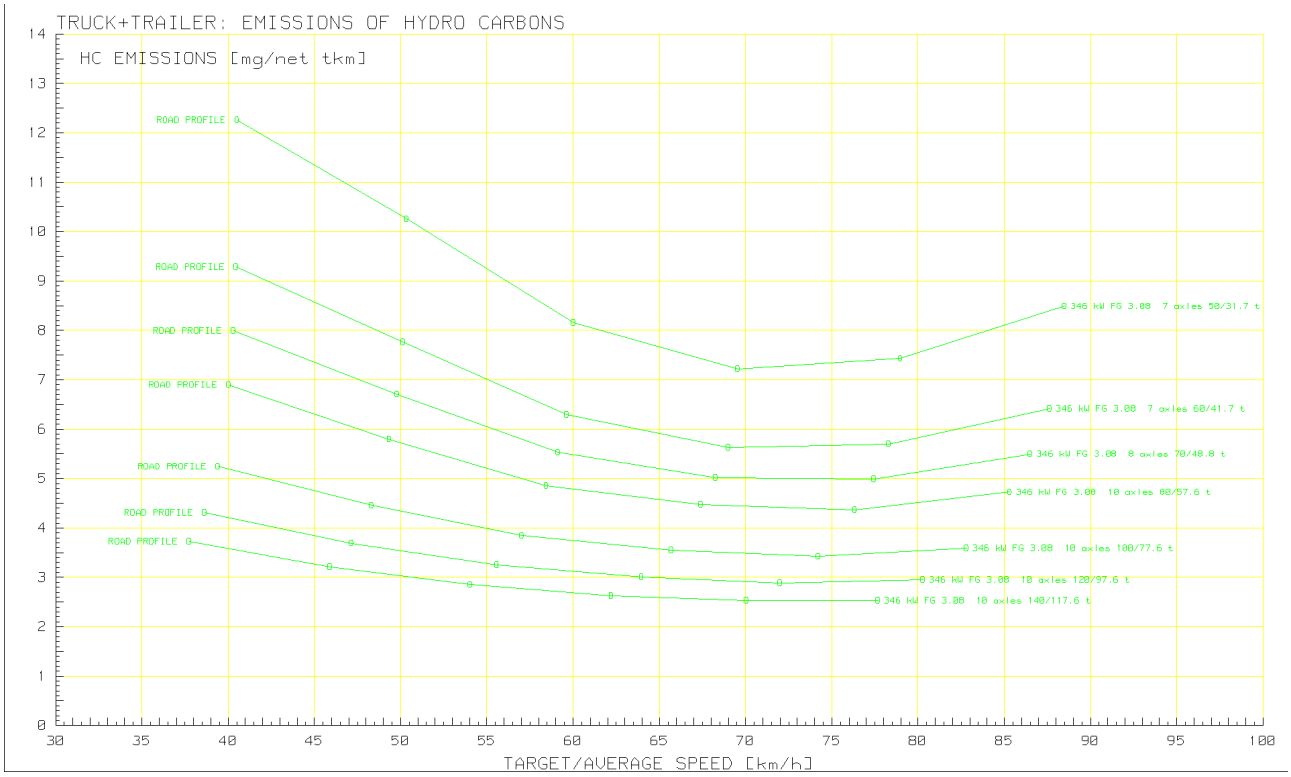

Fig. 10A Emissions of hydro carbons of truck on road profile

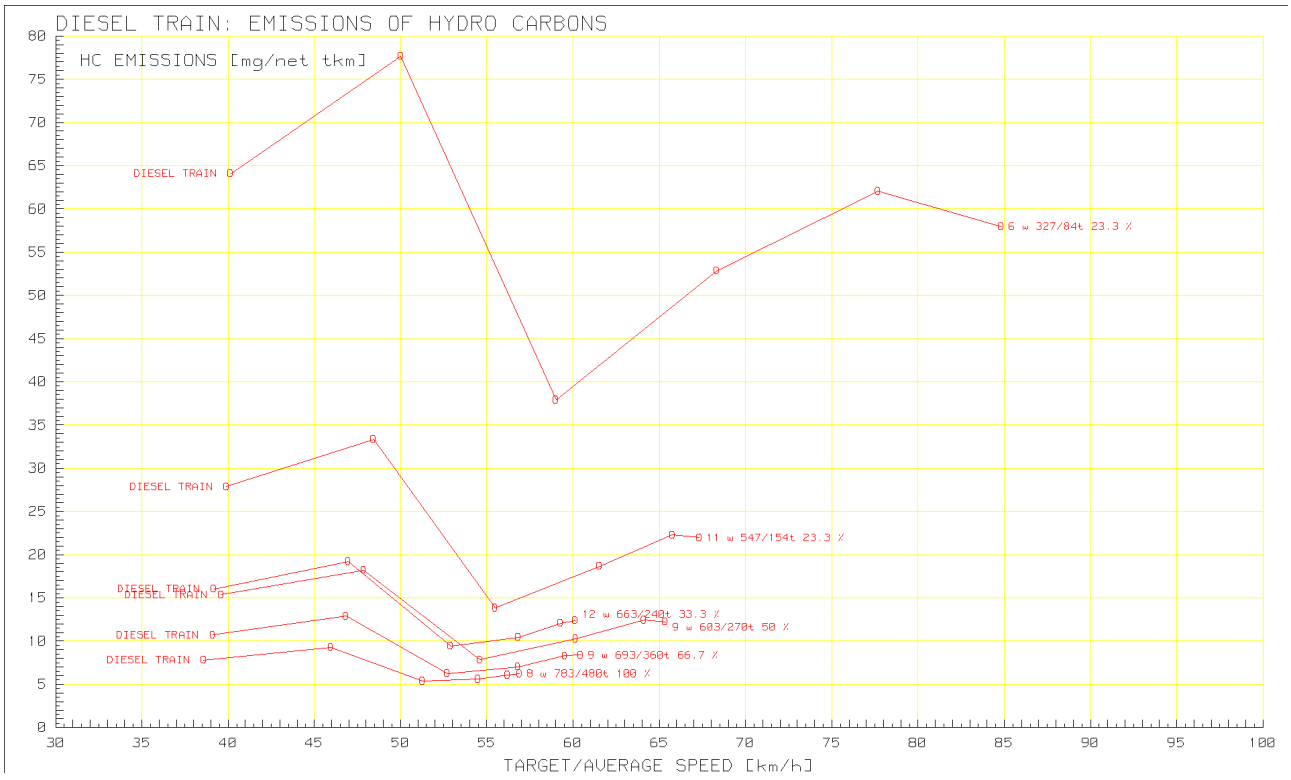

Fig. 10B Emissions of hydro carbons of diesel train