Bike Pedal Power

Crank RPM & Torque, Horsepower and eBike Motors

RPM, Torque & Horsepower Table

Torque in Ft/Lb

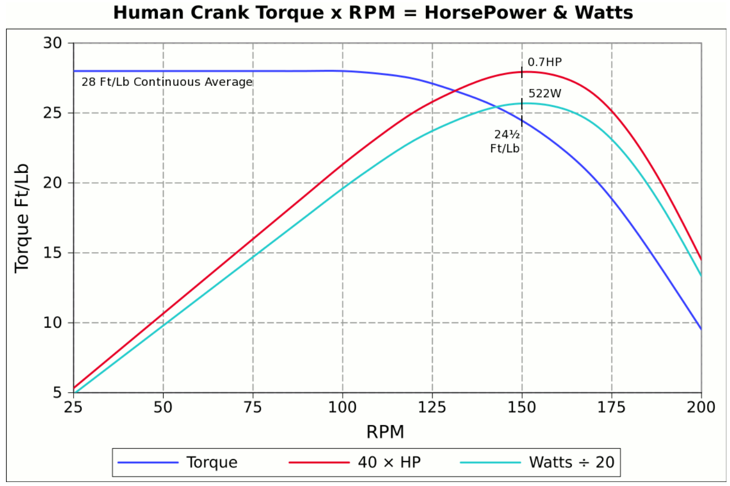
RPM	10	11¼	12½	13¾	15	16¼	17½	18¾	20	21¼	22½	23¾	25	26¼	27½	28¾	30
10	0.019	0.021	0.024	0.026	0.029	0.031	0.033	0.036	0.038	0.040	0.043	0.045	0.048	0.050	0.052	0.055	0.057
15	0.029	0.032	0.036	0.039	0.043	0.046	0.050	0.054	0.057	0.061	0.064	0.068	0.071	0.075	0.079	0.082	0.086
20	0.038	0.043	0.048	0.052	0.057	0.062	0.067	0.071	0.076	0.081	0.086	0.090	0.095	0.100	0.105	0.109	0.114
25	0.048	0.054	0.060	0.065	0.071	0.077	0.083	0.089	0.095	0.101	0.107	0.113	0.119	0.125	0.131	0.137	0.143
30	0.057	0.064	0.071	0.079	0.086	0.093	0.100	0.107	0.114	0.121	0.129	0.136	0.143	0.150	0.157	0.164	0.171
35	0.067	0.075	0.083	0.092	0.100	0.108	0.117	0.125	0.133	0.142	0.150	0.158	0.167	0.175	0.183	0.192	0.200
40	0.076	0.086	0.095	0.105	0.114	0.124	0.133	0.143	0.152	0.162	0.171	0.181	0.190	0.200	0.209	0.219	0.228
45	0.086	0.096	0.107	0.118	0.129	0.139	0.150	0.161	0.171	0.182	0.193	0.203	0.214	0.225	0.236	0.246	0.257
50	0.095	0.107	0.119	0.131	0.143	0.155	0.167	0.179	0.190	0.202	0.214	0.226	0.238	0.250	0.262	0.274	0.286
55	0.105	0.118	0.131	0.144	0.157	0.170	0.183	0.196	0.209	0.223	0.236	0.249	0.262	0.275	0.288	0.301	0.314
60	0.114	0.129	0.143	0.157	0.171	0.186	0.200	0.214	0.228	0.243	0.257	0.271	0.286	0.300	0.314	0.328	0.343
65	0.124	0.139	0.155	0.170	0.186	0.201	0.217	0.232	0.248	0.263	0.278	0.294	0.309	0.325	0.340	0.356	0.371
70	0.133	0.150	0.167	0.183	0.200	0.217	0.233	0.250	0.267	0.283	0.300	0.317	0.333	0.350	0.367	0.383	0.400
75	0.143	0.161	0.179	0.196	0.214	0.232	0.250	0.268	0.286	0.303	0.321	0.339	0.357	0.375	0.393	0.411	0.428
80	0.152	0.171	0.190	0.209	0.228	0.248	0.267	0.286	0.305	0.324	0.343	0.362	0.381	0.400	0.419	0.438	0.457
85	0.162	0.182	0.202	0.223	0.243	0.263	0.283	0.303	0.324	0.344	0.364	0.384	0.405	0.425	0.445	0.465	0.486
90	0.171	0.193	0.214	0.236	0.257	0.278	0.300	0.321	0.343	0.364	0.386	0.407	0.428	0.450	0.471	0.493	0.514
95	0.181	0.203	0.226	0.249	0.271	0.294	0.317	0.339	0.362	0.384	0.407	0.430	0.452	0.475	0.497	0.520	0.543
100	0.190	0.214	0.238	0.262	0.286	0.309	0.333	0.357	0.381	0.405	0.428	0.452	0.476	0.500	0.524	0.547	0.571
105	0.200	0.225	0.250	0.275	0.300	0.325	0.350	0.375	0.400	0.425	0.450	0.475	0.500	0.525	0.550	0.575	0.600
110	0.209	0.236	0.262	0.288	0.314	0.340	0.367	0.393	0.419	0.445	0.471	0.497	0.524	0.550	0.576	0.602	0.628
115	0.219	0.246	0.274	0.301	0.328	0.356	0.383	0.411	0.438	0.465	0.493	0.520	0.547	0.575	0.602	0.630	0.657
120	0.228	0.257	0.286	0.314	0.343	0.371	0.400	0.428	0.457	0.486	0.514	0.543	0.571	0.600	0.628	0.657	0.685
125	0.238	0.268	0.298	0.327	0.357	0.387	0.417	0.446	0.476	0.506	0.536	0.565	0.595	0.625	0.655	0.684	0.714
130	0.248	0.278	0.309	0.340	0.371	0.402	0.433	0.464	0.495	0.526	0.557	0.588	0.619	0.650	0.681	0.712	0.743
135	0.257	0.289	0.321	0.353	0.386	0.418	0.450	0.482	0.514	0.546	0.578	0.610	0.643	0.675	0.707	0.739	0.771
140	0.267	0.300	0.333	0.367	0.400	0.433	0.466	0.500	0.533	0.566	0.600	0.633	0.666	0.700	0.733	0.766	0.800
145	0.276	0.311	0.345	0.380	0.414	0.449	0.483	0.518	0.552	0.587	0.621	0.656	0.690	0.725	0.759	0.794	0.828
150	0.286	0.321	0.357	0.393	0.428	0.464	0.500	0.536	0.571	0.607	0.643	0.678	0.714	0.750	0.785	0.821	0.857
155	0.295	0.332	0.369	0.406	0.443	0.480	0.516	0.553	0.590	0.627	0.664	0.701	0.738	0.775	0.812	0.848	0.885
160	0.305	0.343	0.381	0.419	0.457	0.495	0.533	0.571	0.609	0.647	0.685	0.724	0.762	0.800	0.838	0.876	0.914
165	0.314	0.353	0.393	0.432	0.471	0.511	0.550	0.589	0.628	0.668	0.707	0.746	0.785	0.825	0.864	0.903	0.942
170	0.324	0.364	0.405	0.445	0.486	0.526	0.566	0.607	0.647	0.688	0.728	0.769	0.809	0.850	0.890	0.931	0.971
175	0.333	0.375	0.417	0.458	0.500	0.541	0.583	0.625	0.666	0.708	0.750	0.791	0.833	0.875	0.916	0.958	1.000
180	0.343	0.386	0.428	0.471	0.514	0.557	0.600	0.643	0.685	0.728	0.771	0.814	0.857	0.900	0.942	0.985	1.028
185	0.352	0.396	0.440	0.484	0.528	0.572	0.616	0.660	0.704	0.749	0.793	0.837	0.881	0.925	0.969	1.013	1.057
190	0.362	0.407	0.452	0.497	0.543	0.588	0.633	0.678	0.724	0.769	0.814	0.859	0.904	0.950	0.995	1.040	1.085
195	0.371	0.418	0.464	0.511	0.557	0.603	0.650	0.696	0.743	0.789	0.835	0.882	0.928	0.975	1.021	1.067	1.114
200	0.381	0.428	0.476	0.524	0.571	0.619	0.666	0.714	0.762	0.809	0.857	0.904	0.952	1.000	1.047	1.095	1.142

Horsepower is calculated using: Torque × RPM ÷ 5252

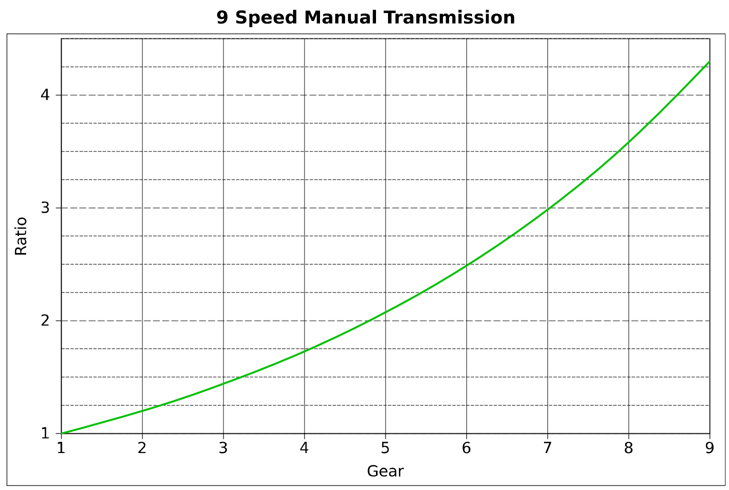
The torque is a continuous average and not peak pulses as what is probably used in John Bump's 1999 document where peak torque can be as high as 5-6 times the average with a median of 5⅖.

The original document can found be here: Bicycle Efficiency and Power
If not available here is a copy: Bicycle Efficiency and Power

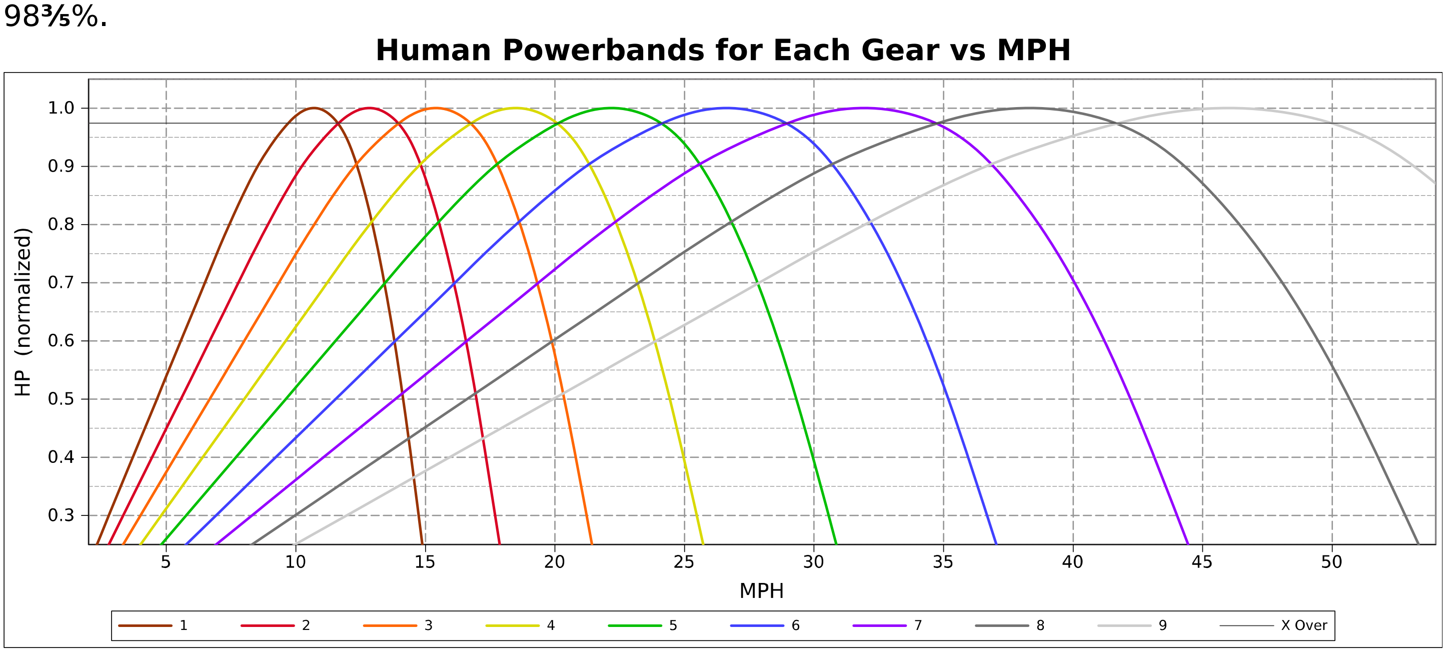
Here are graphs using average torque, RPM & HP, a 9 speed manual transmission gearbox, gear powerbands, and an eBike Motor.



The 1st graph→ is for a trained cyclist on a short sprint however a top cyclist might exceed 1HP.



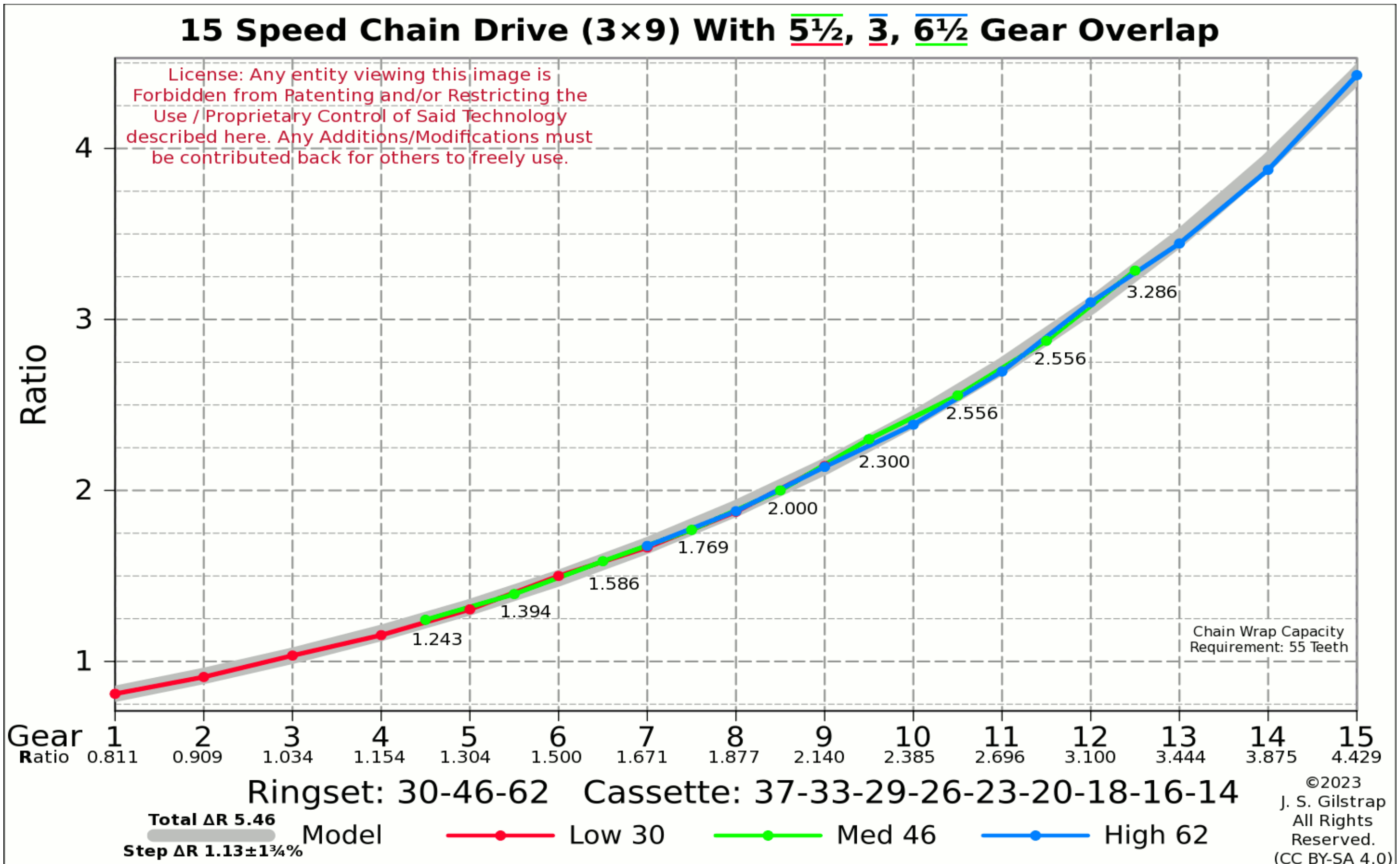
The benefits of using a gearbox instead of chain and cassette gears can outweigh it especially if the efficiency is >90%. Using precision ground helical or herringbone gears this can provide up to 98% efficiency per gear mesh but >2 meshings may reduce it to <95%. Some benefits are low maintenance, protection from the elements, and better ratio spacing. It is possible to produce a gearbox that has a consistent gear spacing so no matter what gear is used the power band is always the same width. In the 2nd graph→ to the right there is a 20% increase between each gear. This can be accomplished using two 3-speed gearsets connected in series. The 1st set would a ratio Δ of 1⅕ 1.2, the 2nd set a Δ of (1⅕)^3 1.728, and from low to high gear a total Δ of 4.3 . Many use multi planetary gearsets like a Rohloff hub which has 14 gears and a total Δ of 5¼. Although not as compact a similar layout like a car manual transmission could provide a more robust and perfect ratio spacing where a planetary set may not. If used on a recumbent trike space is less of a premium and if made with lightweight and strong metals this could be a better option. A 3×4 speed gearbox setup would provide 12 gears with a closer ratio Δ of $1\frac{1}{7}$ 1.143, a total Δ of 4⅓, and a power crossover of 98⅗%.

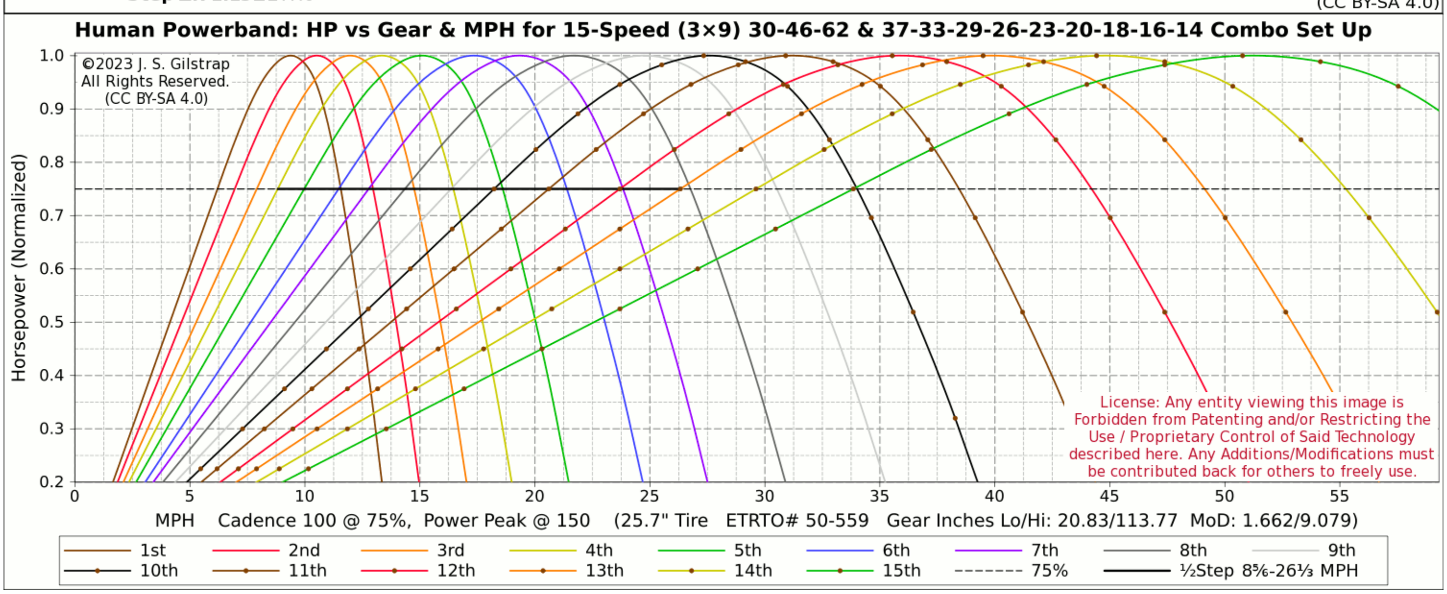


Based on the HP curve in the 1st graph a 20% gear spacing creates power crossover points at 97⅖% of peak power.

In the 3rd graph↑ the gear spread across the speed range is dependent upon the final drive ratio like the rear end in a car, in this case the pre-drive front ringset for pedaling going into the transmission. The 97⅖% crossover level of 9th gear is set at 50mph. Depending on drag coefficient this may be too high for 1HP of power especially for an open setup. If so then the final drive ratio should be geared lower. For a velomobile it may be fine on flat terrain, tailwind or going downhill. In the U.S. eBike power without a license is limited to 750W/1HP and 28mph but your pedal power can exceed this if you have it. Also to consider is the motor's power roll off at 95rpm of crank cadence however a top professional rider's cadence can roll off at 165rpm. In this case the motor peak for 9th gear would be 29mph instead of 50mph in the graph. **Cadence HP Roll Off vs MPH in Each Gear →**

Gear	Motor RPM	Pedal Cadence
	95	165
1	6.7	11.6
2	8.0	14.0
3	9.6	16.7
4	11.6	20.1
5	13.9	24.1
6	16.7	28.9
7	20.0	34.7
8	24.0	41.7
9	28.8	50.0





MPH to Cadence RPM Tables for 30-46-62 Ringset & 37-33-29-26-23-20-18-16-14 Cassette using a 26” Tire

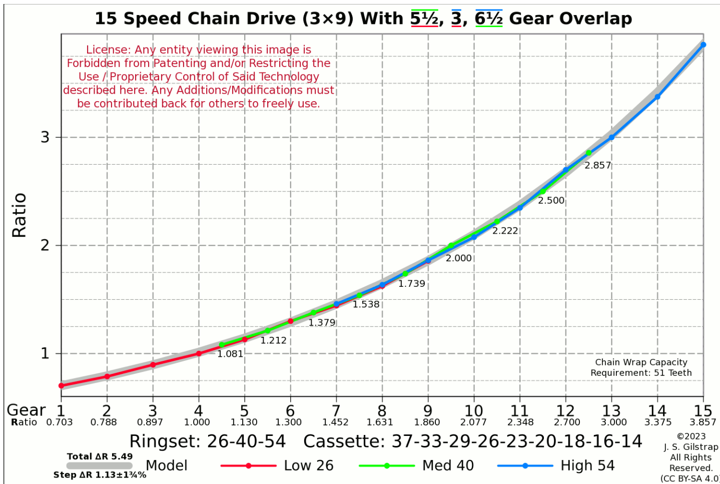
						30				
		37	33	29	26	23	20	18	16	14
MPH	KPH	0.811	0.909	1.034	1.154	1.304	1.500	1.667	1.875	2.143
3.75	6.04	60.5	54.0	47.4	42.5	37.6	32.7	29.4	26.2	22.9
7.50	12.07	121.0	107.9	94.9	85.0	75.2	65.4	58.9	52.3	52.8
11.25	18.11	181.5	161.9	142.3	127.6	112.9	98.1	88.3	78.5	68.7
15.00	24.14	242.1	1215.9	189.7	170.1	150.5	130.8	117.8	104.7	94.6
18.75	30.18	302.6	269.9	237.1	212.6	188.1	163.6	147.2	130.8	114.5
22.50	36.21	363.1	323.8	284.6	255.1	225.7	196.3	176.6	157.0	137.4
26.25	42.25	423.6	377.8	332.0	297.7	263.3	229.0	206.1	183.2	160.3
30.00	48.28	484.1	431.8	379.4	340.2	300.9	261.7	235.5	209.3	183.2

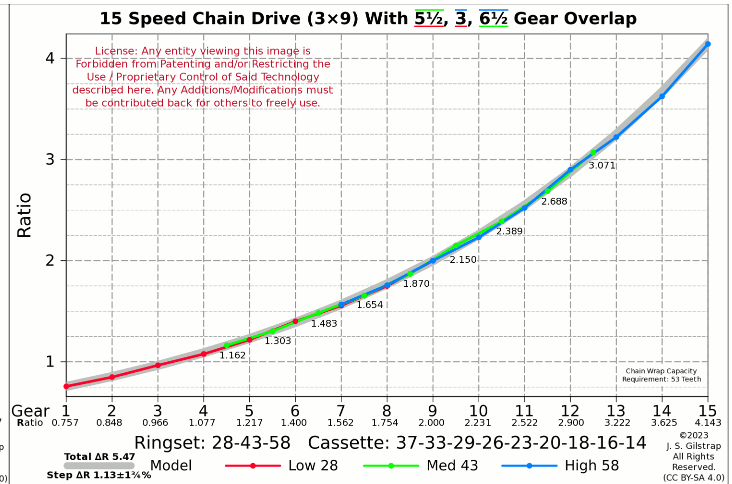
						46				
		37	33	29	26	23	20	18	16	14
MPH	KPH	1.243	1.394	1.586	1.769	2.000	2.300	2.556	2.875	3.286
3.75	6.04	39.5	35.2	30.9	27.7	24.5	21.3	19.2	17.1	14.9
7.50	12.07	78.9	70.4	61.9	55.5	49.1	42.7	38.4	34.1	29.9
11.25	18.11	118.4	105.6	92.8	83.2	73.6	64.0	57.6	51.2	44.8
15.00	24.14	157.9	140.8	123.7	110.9	98.1	85.3	76.8	68.3	59.7
18.75	30.18	197.3	176.0	154.7	138.7	122.7	106.7	96.0	85.3	74.7
22.50	36.21	236.8	211.2	185.6	166.4	147.2	128.0	115.2	102.4	89.6
26.25	42.25	276.8	246.4	216.5	194.1	171.7	149.3	134.4	119.5	104.5
30.00	48.28	315.7	281.6	247.5	221.9	196.3	170.7	153.6	136.5	119.5
33.75	54.32	355.2	316.8	278.4	249.6	220.8	192.0	172.8	153.6	134.4
37.50	60.35	394.7	352.0	309.3	277.3	245.3	213.3	192.0	170.7	149.3
41.25	66.39	434.1	387.2	340.1	305.1	269.9	234.7	211.2	187.7	164.3
45.00	72.42	473.6	422.4	371.2	332.8	294.4	256.0	230.4	204.8	179.2

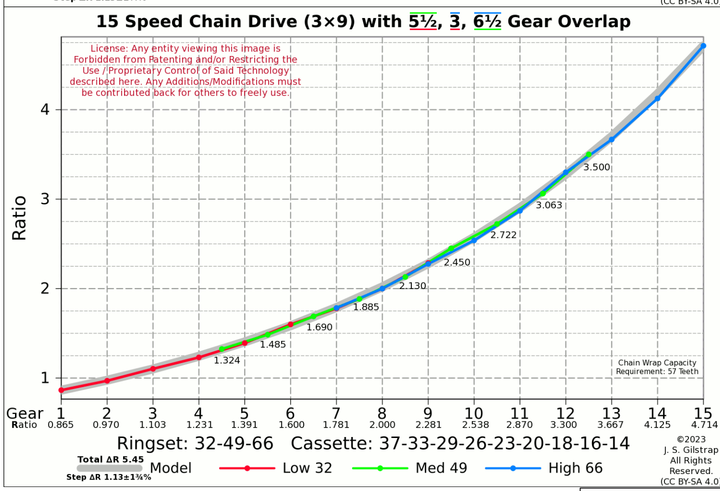
						62				
		37	33	29	26	23	20	18	16	14
MPH	KPH	1.676	1.879	2.138	2.385	2.696	3.100	3.444	3.875	4.429
3.75	6.04	29.3	26.1	22.9	20.6	18.2	15.8	14.2	12.7	11.1
7.50	12.07	58.6	52.2	45.9	41.2	36.4	31.7	28.5	25.3	22.2
11.25	18.11	87.8	78.3	68.8	61.7	54.6	47.5	42.7	38.0	33.2
15.00	24.14	117.1	104.5	91.8	82.3	72.8	63.3	57.0	50.6	44.3
18.75	30.18	146.4	130.6	114.7	102.9	91.0	79.1	71.2	63.3	55.4
22.50	36.21	175.7	156.7	137.7	123.5	109.2	95.0	85.5	76.0	66.5
26.25	42.25	205.0	182.8	160.6	144.0	127.4	110.8	99.7	88.6	77.6
30.00	48.28	234.2	208.9	183.6	164.6	145.6	126.6	114.0	101.3	88.6
33.75	54.32	263.5	235.0	206.5	185.2	163.8	142.4	128.2	114.0	99.7
37.50	60.35	292.8	261.2	229.5	205.8	182.0	158.3	142.4	126.6	110.7
41.25	66.39	322.1	287.3	252.4	226.3	200.2	174.1	156.7	139.3	121.9
45.00	72.42	351.4	313.4	275.4	246.9	218.4	189.9	170.9	151.9	133.0
48.75	78.46	380.7	339.5	298.3	267.5	236.6	205.8	185.2	164.6	144.0
52.50	84.49	409.9	365.6	321.3	288.1	254.8	221.6	199.4	177.3	155.1
56.25	90.53	439.2	391.7	344.2	308.6	273.0	237.4	213.7	189.9	166.2
60.00	96.56	468.5	417.8	367.2	329.2	291.2	253.2	227.9	202.8	177.3

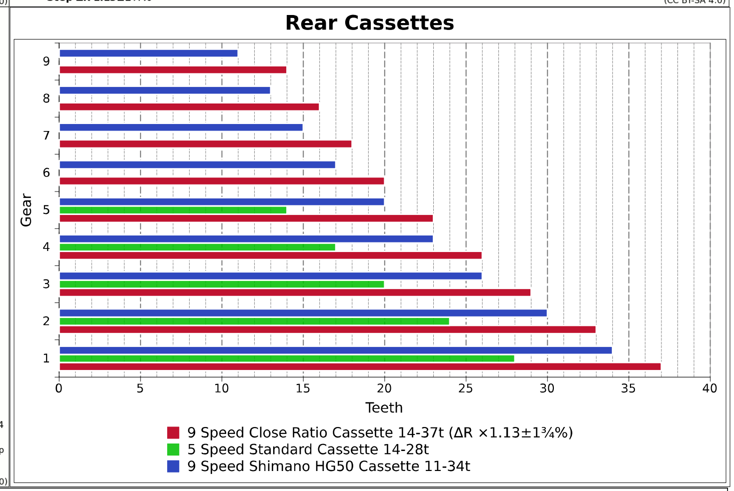
Other Ringset Combos for Cassette Below and Here: 24-37-50, 34-52-70, 36-55-74

Using an Oval Ringset of ±6½% (13⅖% elliptical) can reduce fatigue and increase duration performance.





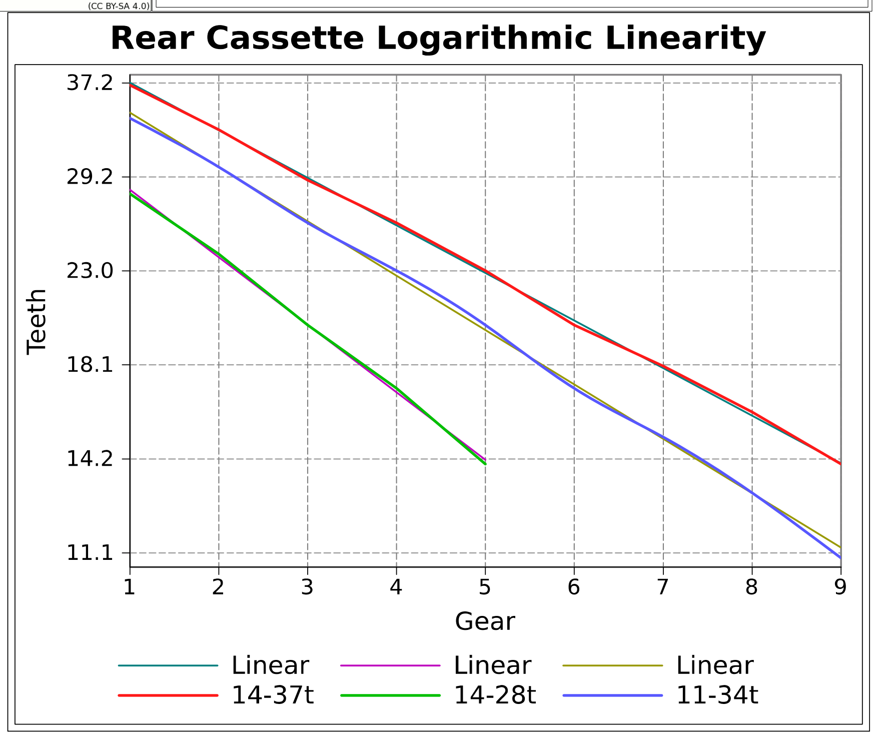




11½ speed Setups (2×8) w/ 4½ Overlap

Ringsets w/33-29-26-23-20-18-16-14 Cassette

34-52 36-55 38-58 39-60 40-61
41-63 42-64 43-66 45-69 47-72



14 speed Setups (3×7) w/ 3½ & 4½ Overlap

Ringsets w/29-26-23-20-18-16-14 Cassette

- 24-42-57 – 1 0.827, 14 4.071, ΔR 4.920
- 26-45-61 – 1 0.897, 14 4.357, ΔR 4.860
- 28-49-66 – 1 0.966, 14 4.714, ΔR 4.883

14 speed Setups (3×8) w/ 4½, 2, 5½ Overlap

Ringsets w/33-29-26-23-20-18-16-14 Cassette

- 25-38-52 – 1 0.758, 14 3.714, ΔR 4.896
- 30-46-62 – 1 0.909, 14 4.429, ΔR 4.871
- 31-47-64 – 1 0.939, 14 4.571, ΔR 4.866
- 32-49-66 – 1 0.970, 14 4.714, ΔR 4.862
- 33-50-68 – 1 1.000, 14 4.857, ΔR 4.857

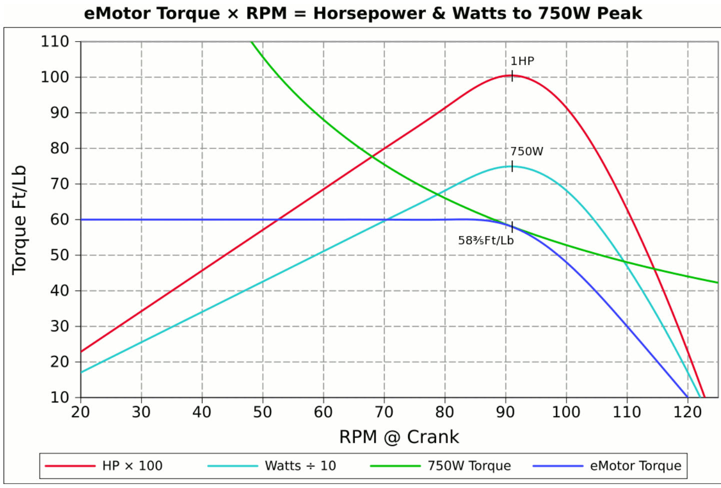
16 speed Setups (3×8) w/ 2½ & 4½ Overlap

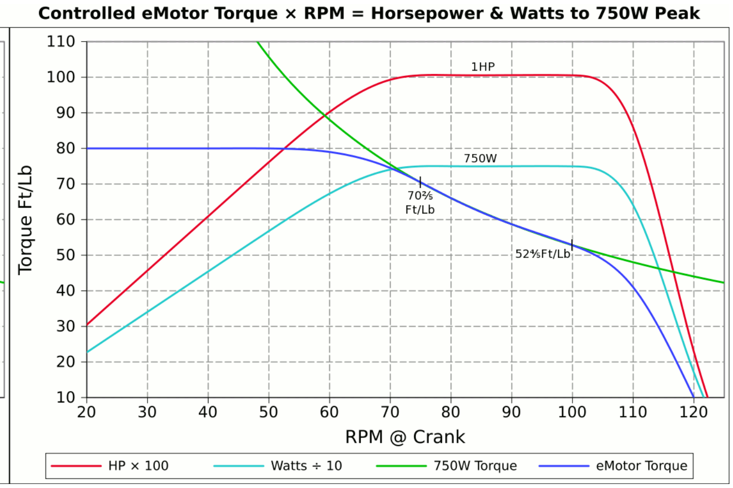
Ringsets w/33-29-26-23-20-18-16-14 Cassette

- 22-38-58 – 1 0.667, 16 4.143, ΔR 6.214
- 23-40-61 – 1 0.697, 16 4.357, ΔR 6.251
- 25-44-67 – 1 0.756, 16 4.786, ΔR 6.317
- 26-45-69 – 1 0.788, 16 4.928, ΔR 6.255
- 28-49-75 – 1 0.848, 16 5.357, ΔR 6.314

For the 15 Speed 3×9 combo setups on pages 3 & 5, although not perfect, the uniformly spaced gears rival that of a Rohloff 14 Speed hub and exceeds its gear range, efficiency and high stress durability for many hundred$ less. No Respoking Required. The low and high chain rings are gear aligned while the middle ring is offset by ½ gear providing an ~6.3% gear increment within the ringset over the most used range. ½ gear alignment on average is within a 45/55 % split, a couple may be close to a 50/50 % split, while only one approaches a 33/66 % split. While switching between rings is not as convenient for longer distances this will provide an additional level of fine tuning for optimized power efficiency.

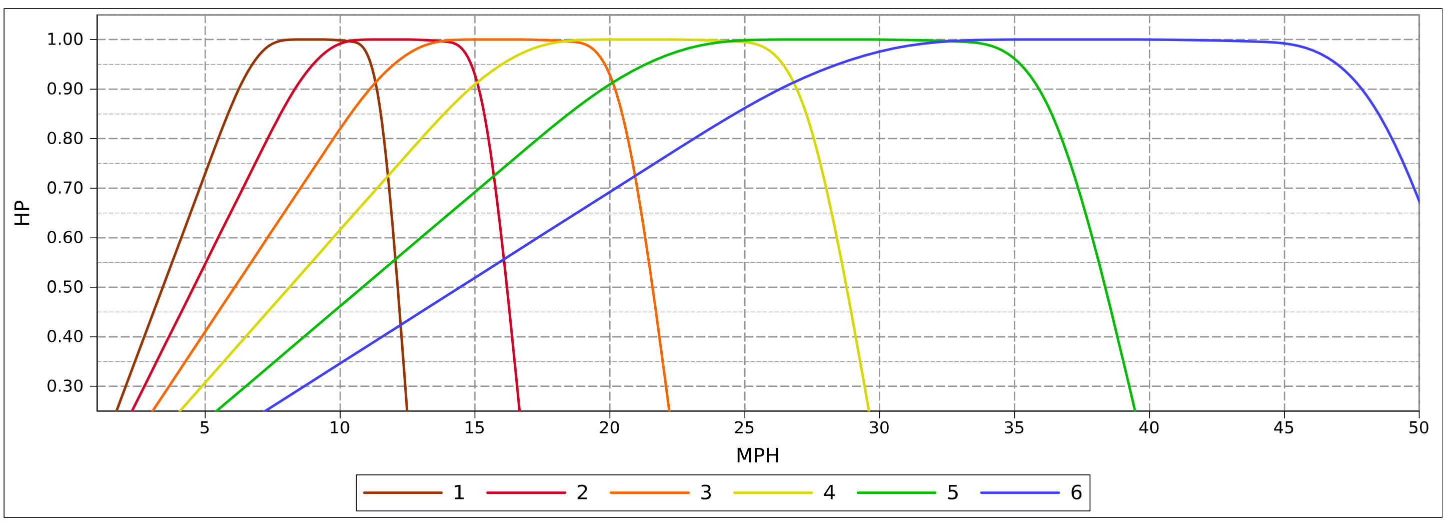
Motors for eBikes





The 6th graph↑ is of a 3-phase brushless DC motor which shows a torque curve that would produce a constant 1HP output however most motors have a flat torque curve before it rolls off at its unloaded RPM. With a flat curve the **HP** & **W** curves produce a proportional increase with increasing RPM until it peaks at 1.006HP before it rolls off. Peak DC motor RPM is usually in the 1000s so a gear reduction is necessary to produce a power roll off at 95rpm of the crank. This is suitable for amateurs and most experienced non-professional riders. The 7th graph↑ shows a contoured torque curve that offers a nice wide and flat 1HP powerband. A 6 speed transmission in a non-pedal version using a ratio Δ of 1⅓ and a total Δ of 4⅕ would provide a gear↓spread with a completely flat 1HP response from 8 to 45 mph.

Motor Powerbands for Each Gear vs MPH



An open source spreadsheet was used to create these graphs.
Gnumeric Free, Fast, Accurate – Pick Any Three!

This worksheet was used to create some of the graphs: **GearRatio+MPH2CadenceCalculator.gnumeric**
Although not up-to-date and lacking of graphs here is an Excel version: **GearRatio+MPH2CadenceCalculator.xlsx**

It comes with Linux but can also be installed on a Mac. To do so install X11 (Quartz), macports, and at the command line prompt as superuser run: **port install gnumeric** . To run type 'gnumeric &' at the command line prompt . It can also be added to the X11 → Applications menu. There are versions available for Windows also.