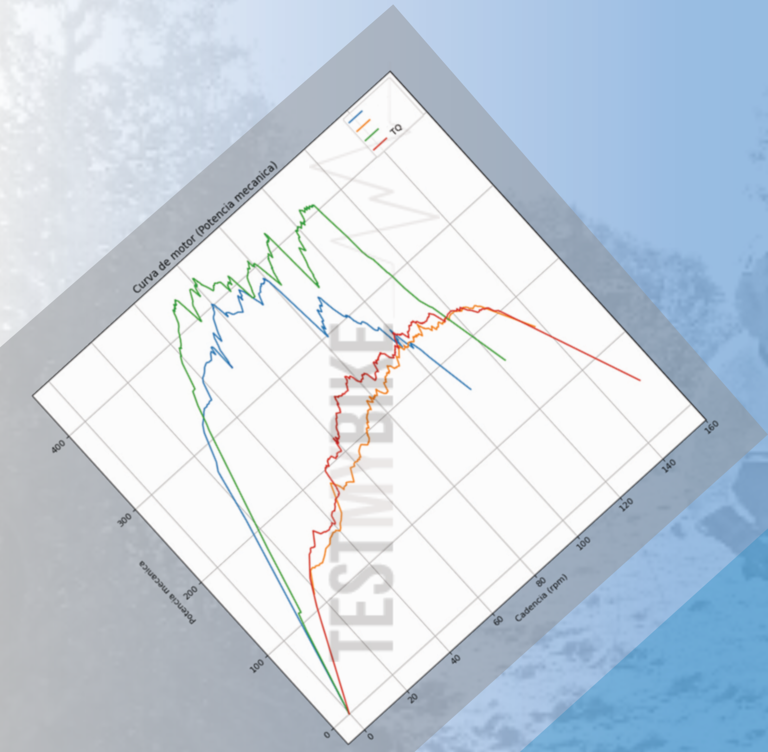
REPORT

TESTMYBIKE

TQ

HPR50

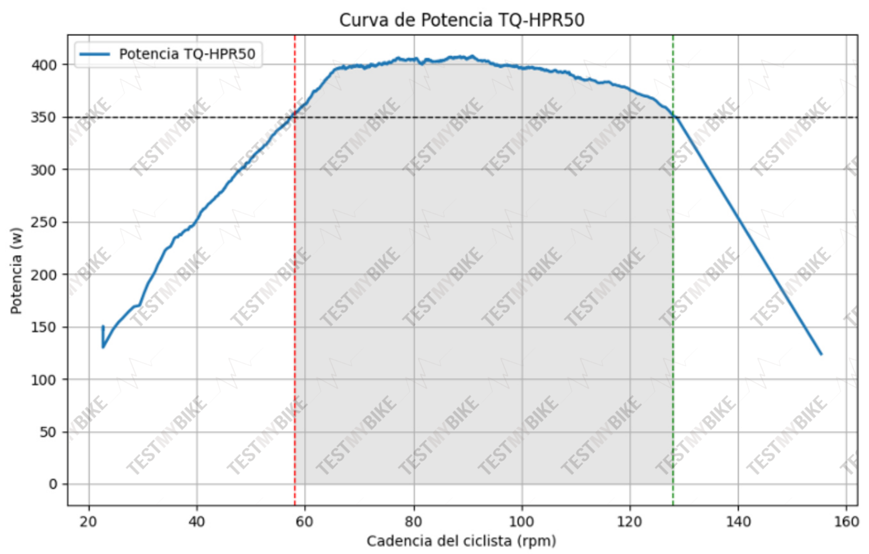


WHAT NO ONE ELSE CAN TELL YOU!

POWER CURVE, EFFICIENCY... AND MUCH MORE!

In the electric bicycle sector, the lack of precise and objective data can lead to a lack of transparency and clear understanding of the real performance of products. At Test My Bike, we provide detailed and accurate data to help make informed decisions and promote greater transparency in the sector.

The power curve and much more is detailed in the report.



At Test My Bike, we have developed a revealing, comprehensive, and thorough report of the new SL e-bike motor from the German brand TQ, specifically the innovative and revolutionary SL HPR50 motor, which boasts 50 Nm of torque and 300 watts of power.

We thoroughly analyzed it on our (patented) power bench and subjected it to our rigorous Test My Bike protocol, not only to verify the scant information provided by the manufacturers, but to provide clearer and more concise information.

The Test My Bike protocol is very comprehensive and includes various field tests combined with laboratory tests. From this compendium of tests, we create our complete and detailed report, as well as our final conclusions. Of course, the new TQ HPR50 motor has gone through all of them.

Don't miss our results and conclusions.

But first, a bit of context:

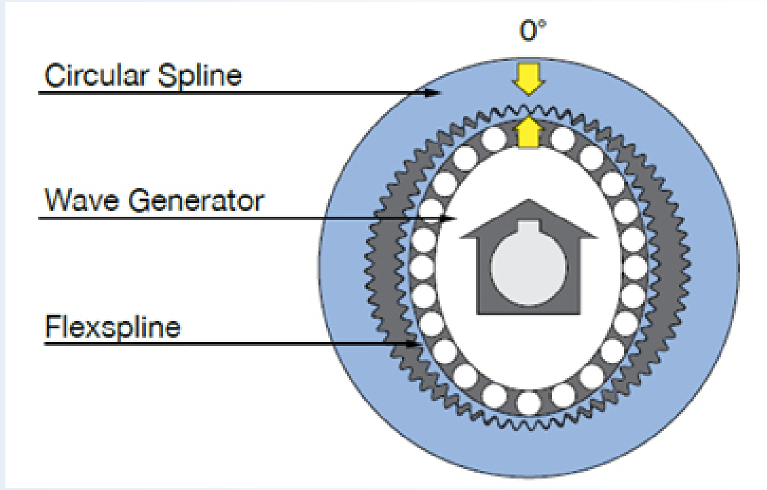
On the move!

The TQ HPR-50 motor uses TQ's patented Harmonic Pin Ring Transmission technology: https://uspto.report/patent/grant/10,371,240. Based on Harmonic Drive technology.

Harmonic Drive transmission technology emerged in the 1950s, following a raw material crisis. Engineers at the time sought a solution to achieve simpler, lighter, more precise, and above all, cheaper to manufacture electric motors.

This transmission technology "reduced" the amount of metal as raw material, and simplified operation by eliminating reduction shafts, generating concentric movement. Simple but, apparently, less efficient than the well-known planetary shaft motors.

TQ takes advantage of the best of this technology, achieving what we all know: compact dimensions and mechanical simplicity unheard of in the e-bike era to date.



Fuente: https://www.harmonicdrive.net/technology

In an interview with Daniel Theil, TQ Product Manager, published by Ebike Rumor, they echo the efficiency problem of Harmonic Drive technology, highlighting that their new Harmonic Pin Ring transmission technology, which is based on Harmonic Drive, does not share its low efficiency. Here is an excerpt from his words:

"For those familiar with traditional harmonic drive systems that are used in aerospace, medical, and robotic applications, the TQ-HPR50 uses a mechanism that is actually quite different from those. While the TQ-HPR50 shares the same high precision and direct engagement of traditional Harmonic Drive systems, it does not share their low efficiency."

"Daniel tells us that it is this mechanism, as well as TQ's special tooth profile, that really improves the HPR50's efficiency compared to traditional harmonic drive systems."

Link: https://bikerumor.com/tq-hpr50-ebike-motor-harmonic-pin-ring-transmission/

But, does it really manage to correct and improve its biggest handicap, efficiency?

Motor to the bench! Let's analyze in depth the new TQ HPR50.

Who is Test My Bike?

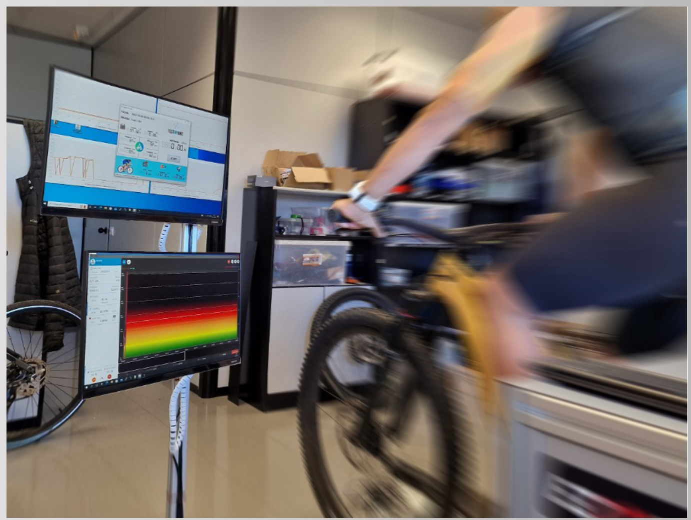
Test My Bike (TMB) is a predominantly technological company that was born with a clear objective: to analyze systems and verify information, as axes of differentiation for the pedal-assist bicycle industry.

Our values highlight: impartiality, honesty, and the tireless fight against the lack of information.

Our unique methodology for analyzing and verifying e-Bikes through data collection and interpretation can or will be extrapolated to all assistance systems, becoming a benchmark in the market. Generally, we seek to provide valuable and enlightening information in a market where there is often confusion.

Currently, we focus on the pedal-assist system of e-Bikes, where we find a great margin for improvement. Among other things, we want to facilitate the understanding of the scarce data available to the public and provide the sector with the real possibility of comparing the different elements that make up the e-Bikes electric system.

In this report, we want to take the opportunity to highlight our collaboration with the Polytechnic University of Madrid (UPM), specifically with the Department of Mechanical Engineering.



This collaboration has been made possible thanks to the support and active participation of Dr. José Luis Muñoz, director of the Department of Mechanical Engineering of the Higher Technical School (ETS), and Dr. Enrique Chacón.

This alliance has allowed the creation of a specialized laboratory, equipped with various patented power benches and state-of-the-art data acquisition systems for field tests.

To these laboratory equipment, a verified data analysis solution is added, where we combine objective data with the sensations of different cyclist profiles. The combination of all this information and its interpretation are the heart of "Test My Bike".

We help our clients (manufacturers and distributors) to deeply understand the electro-mechanical pedal-assist systems, offering clear and concise high-value information, so they can make decisions based on data and not sensations and thus choose the perfect solution for their end customers.

On the other hand, we also want to help e-Bike users who are currently faced with a lack of objective data, preventing them from knowing in detail which product is most suitable for their needs.

1. REPORT GOAL

The purpose of this investigation is to analyze the TQ HPR50 motor, with the aim of providing precise and valuable information about its characteristics and performance.

To conduct the research, **Test My Bike used its patented power bench**, which allows precise measurement of the power and efficiency of the TQ HPR50 motor mounted on the Trek Fuel EXe. Additionally, during field tests, a patented device called DataTMB was used, capable of collecting a multitude of magnitudes in real time, such as voltage, current, cadence, speed, and cyclist pulse.

In addition to the above, Test My Bike has developed a method of comparing electric bicycle motors, called the TMB Method, which allows measuring and comparing different motors on the same metric. (base, pattern, etc.)

Test My Bike will soon publish new reports on other pedal-assist systems.

1.1 Our test methodology:

Test My Bike (TMB) Procedure:

1. **Compilation of external data information.** Goal: to know what public data exists about the motor, both from official sources and opinions from other sources.
2. **Understanding the system's software.** Goal: to understand the scope of the possible configurations that the manufacturer allows through firmware, app, etc.
3. **Unsensorized field test of the bicycle.** Goal: to have a first isolated contact, so that the data does not influence the subjectivity of the individual.
4. **Power bench test.** Goal: to extract real data under controlled conditions with our power benches.
5. **Analysis of the data obtained.** Goal: to look for key parameters and verify the perceived sensations.

6. **TMB Team meeting.** Goal: to analyze the data obtained and draw conclusions for field tests.
7. **Field tests with Data TMB.** Goal: to validate previous sensations and data obtained on the power bench.
8. **Joint analysis of all data** and preparation of the **final report.**

2. GENERAL INFORMATION AND DATA FROM THE MANUFACTURER.

MOTOR TQ HPR50

Caracteristicas principales	
Par máximo	50 Nm
Potencia continua nominal	250 W
Potencia máxima	300 W
Clase de protección	IP67
Temperatura de trabajo	-5°C a +40°C / 23°F a 104°F
Temperatura de almacenamiento	0°C a +40°C / -4°F a 104°F
Longitud del eje del pedalier (Factor Q)	135 mm
Peso	1.850 g

Batería	
Capacidad de la batería	360 Wh
Voltaje nominal	50,4 V
Capacidad nominal	6,8 Ah
Energia nominal	360 Wh
Dimensiones	48 mm x 63,5 mm x 370 mm / 1,89" x 2,5" x 14,57"
Clase de protección	IP67
Rango de temperatura de carga	0 °C a 40 °C / 32 °F a 104 °F
Temperatura de funcionamiento	-5 °C a 40 °C / 23 °F a 104 °F
Temperatura de almacenamiento	10 °C a 20 °C / 50 °F a 68 °F
Peso aproximado	1.835 g / 4,04 lbs

Range extender	
Range Extender - Capacidad	160 Wh
Range Extender - Tensión nominal	50,4 V
Range Extender - Capacidad nominal	2,8 Ah
Range Extender - Energia nominal	160 Wh
Lógica de descarga	Cuando se utiliza la e-bike, primero se descarga el Range Extender y luego la Battery.
Range Extender - Dimensiones	⌀ 76 mm, longitud 185 mm
Range Extender - Clase de protección	IP66
Rango de temperatura de carga	0 °C a 40 °C / 32 °F a 104 °F
Temperatura de funcionamiento	-5 °C a 40 °C / 23 °F a 104 °F
Temperatura de almacenamiento	10 °C a 20 °C / 50 °F a 68 °F

Source:

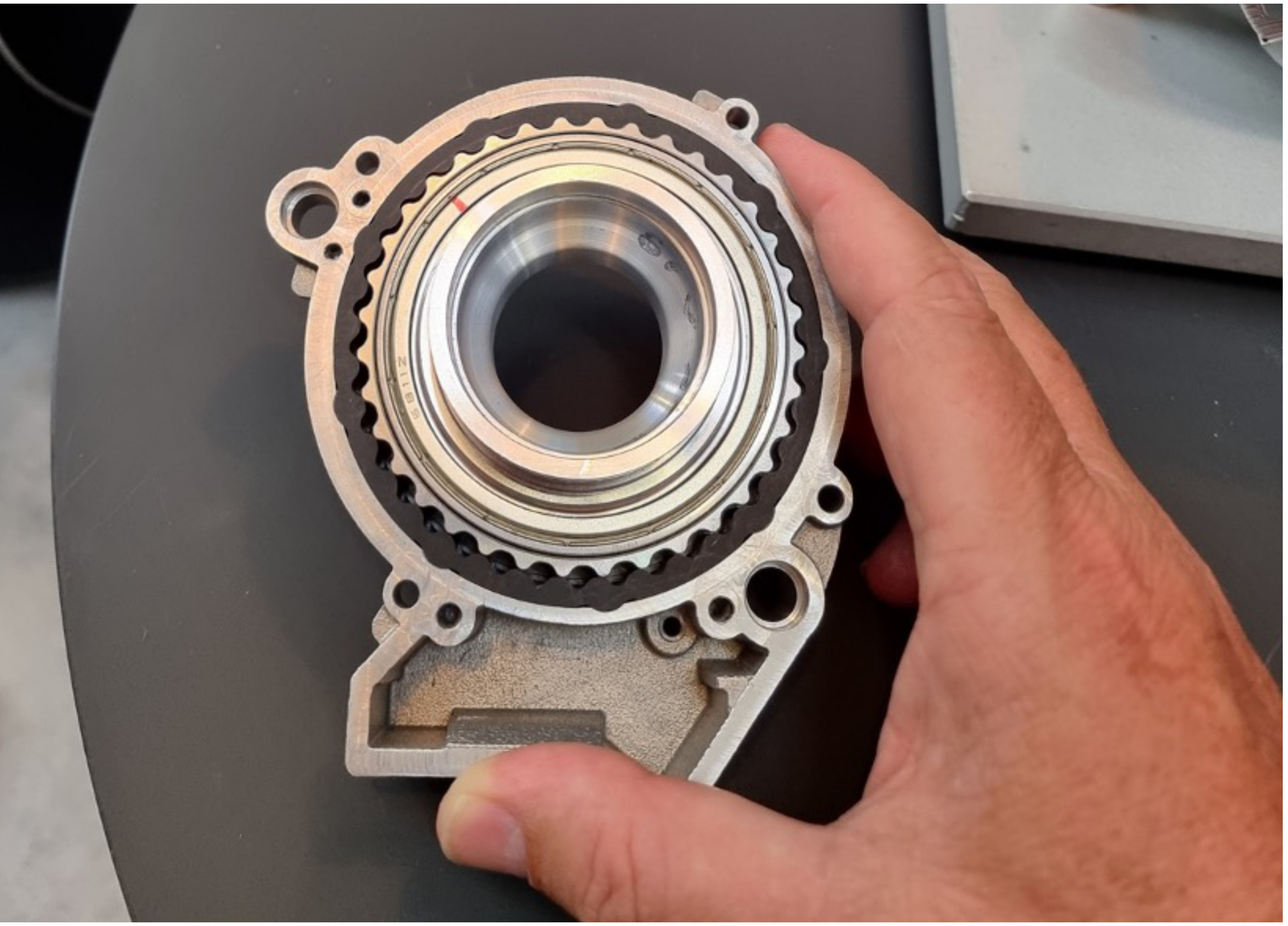
https://www.tq-ebike.com/fileadmin/assets/tq-ebike/downloads/manuals/Drive_Unit/HPR50_Drive_Unit_BHEN_Rev0201_Web_01.pdf

https://www.tq-ebike.com/fileadmin/assets/tq-ebike/downloads/manuals/Battery/HPR50_Battery_BHES_Rev0201_Web_01.pdf

https://www.tq-ebike.com/fileadmin/assets/tq-ebike/downloads/manuals/Range_Extender/HPR50_Range_Extender_BHES_Rev0104_Web.pdf

3. WHAT MAKES THE TQ MOTOR DIFFERENT?

Technologically, it has been a revolution. Its **compact design** allows for very discreet integration, eliminating the visual difference between regular bicycles and e-bikes. Its assembly has positioned it as **one of the weight benchmarks in the market**.



4. THE TQ IN DETAIL

- All tests were conducted aiming for maximum performance.--

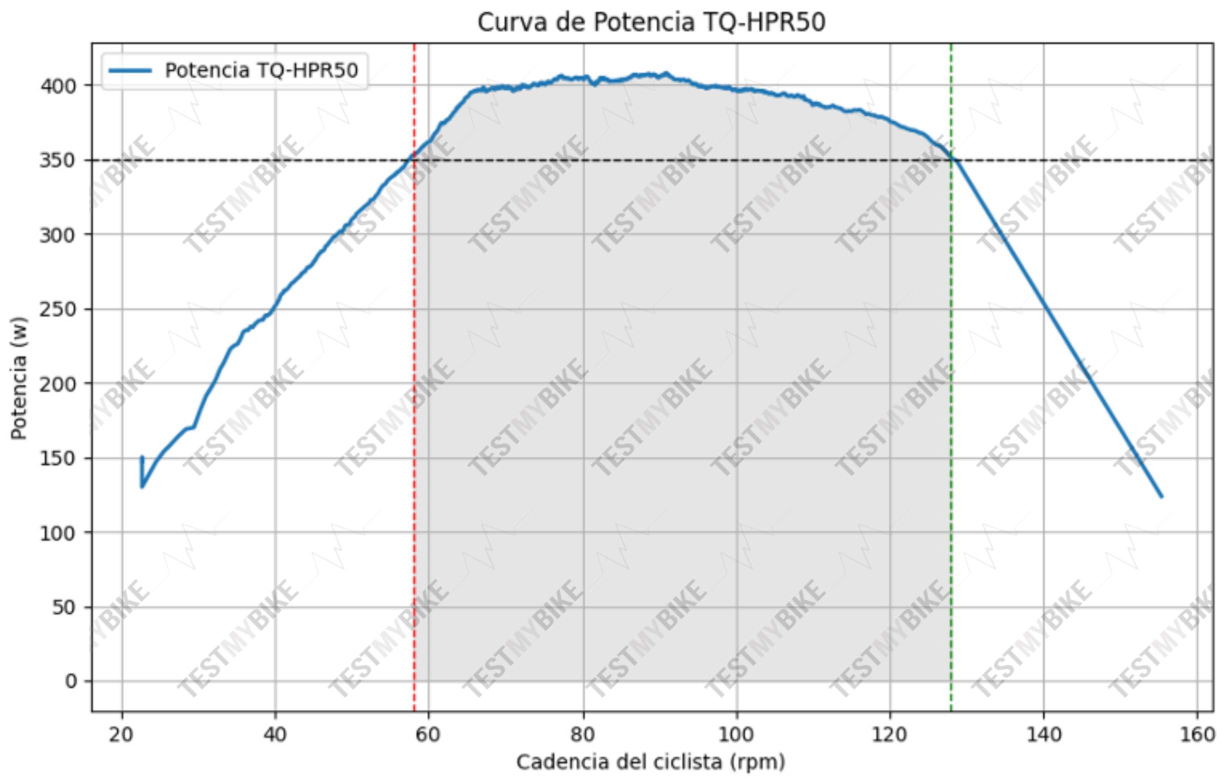
A. Power Curve.

Before analyzing the graph, it is important to understand what we are looking for:

The power curve of an electric motor represents the power generated by the motor in relation to its rotational speed. We will use the cyclist's pedaling cadence to determine this rotational speed. This curve is crucial as it defines the motor's behavior at different cadence ranges, allowing us to evaluate if the motor adapts to the cyclist's characteristics. Additionally, it helps e-bike manufacturers determine if a motor meets the needs of their target audience.

The power curve is displayed on a graph with two axes: the X-axis represents the rotational speed (in RPM or revolutions per minute), and the Y-axis represents the motor's power (in watts).

In this case, we present the power curve of the renowned TQ HPR-50 motor.



During our tests, we confirmed that the TQ HPR-50 motor reaches its maximum power between 60 and 130 RPM of the cyclist's cadence. We also observed that the motor's electric power remains constant, at 400 W of electric power, within this cadence range.

B. Long Duration Test.

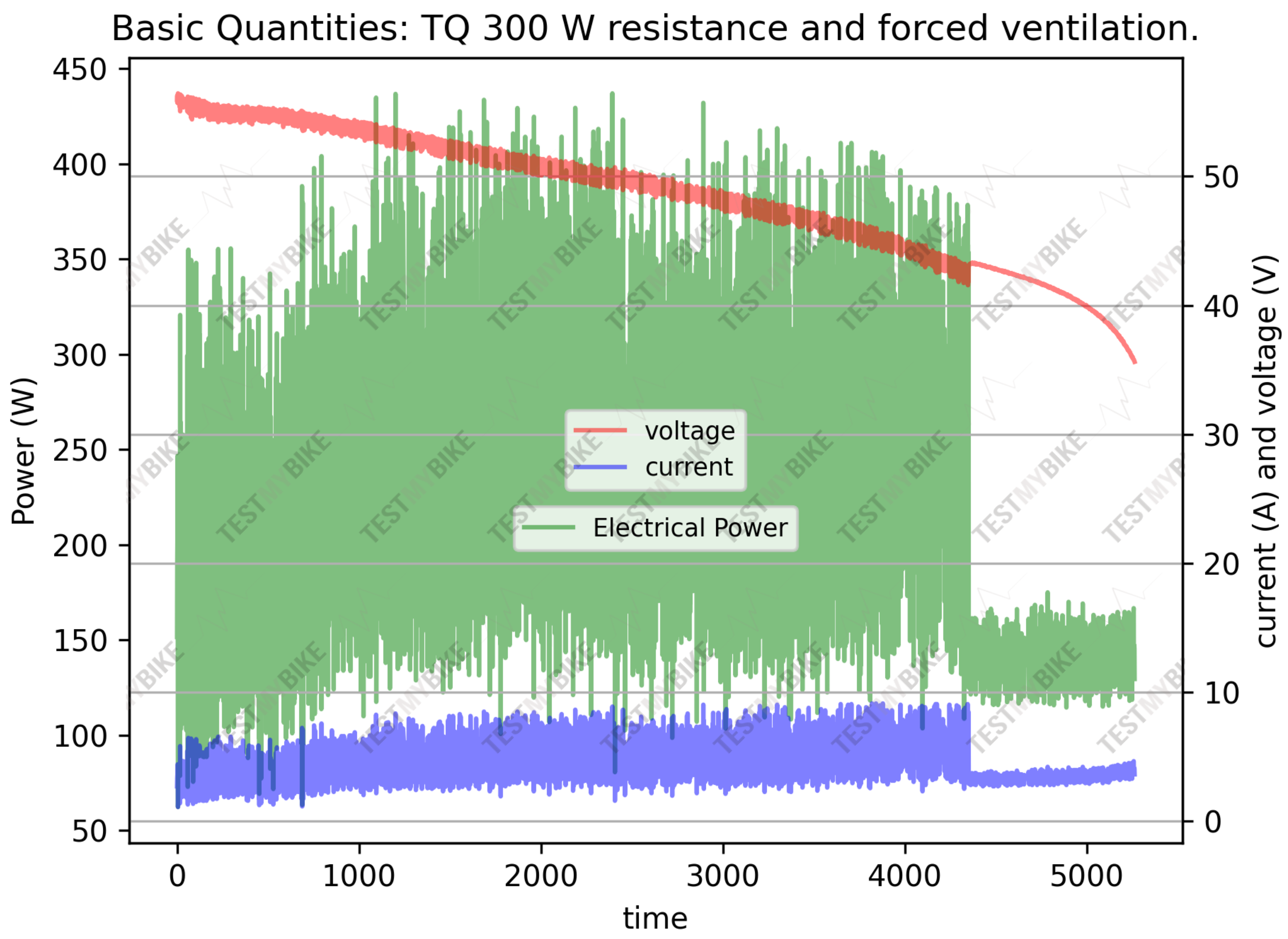
Before analyzing the graph, it is important to explain its purpose and how we obtained it.

Following our established protocol, we set a constant resistance, maintain the cadence at the most favorable range for the system (80 RPM), and apply a controlled power by the cyclist of around 150 watts. This test is always conducted in turbo mode, using the manufacturer's default parameters.

The objective is to analyze the motor's behavior under different applied resistance conditions, simulating real rolling resistances (inclines) of 300 watts and 400 watts, this time with forced ventilation and monitoring the motor's temperature.

The test is considered complete when we deplete the battery and the motor stops providing assistance.

b.1 Long Duration Test at 300 watts of resistance. TQ HPR50.

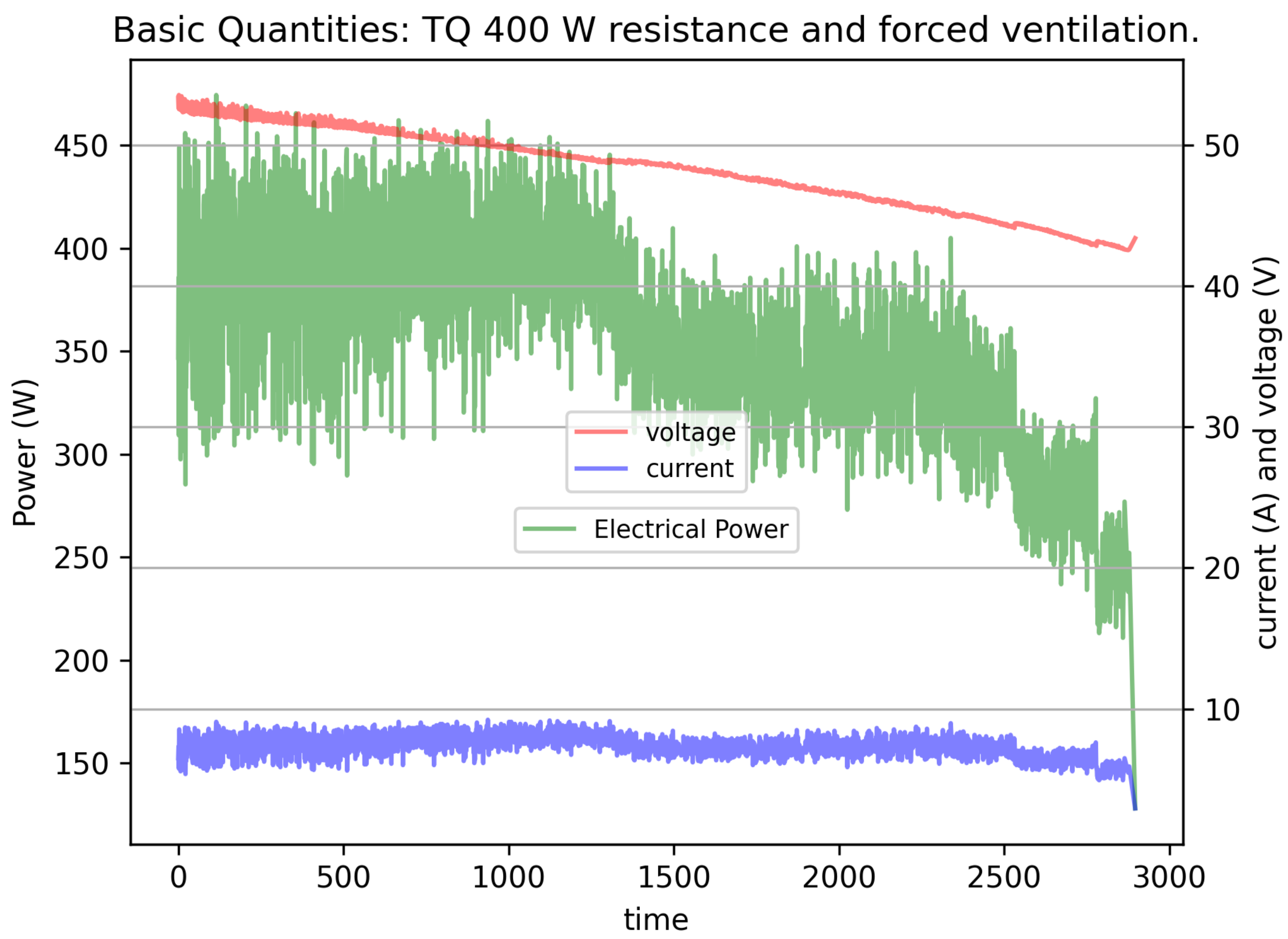


The first thing we notice is a significant variation in power delivery (green color). Let's remember that the test maintains a constant resistance of 300 watts, a cadence of 80 RPM, and a cyclist-applied power of around 150 watts. Our specialists perceive this variability as if the power delivery has some "jerks" (the wider the green band, the greater the variability in power delivery).

Additionally, it is important to note that after 65 minutes, the TQ HPR50 motor automatically switches from turbo mode to eco mode, significantly limiting its power delivery.

Based on the results of this test, we decided to increase the resistance (incline) and repeat the test at 400 watts of resistance.

b.2 Long Duration Test at 400 watts of resistance. TQ HPR-50.



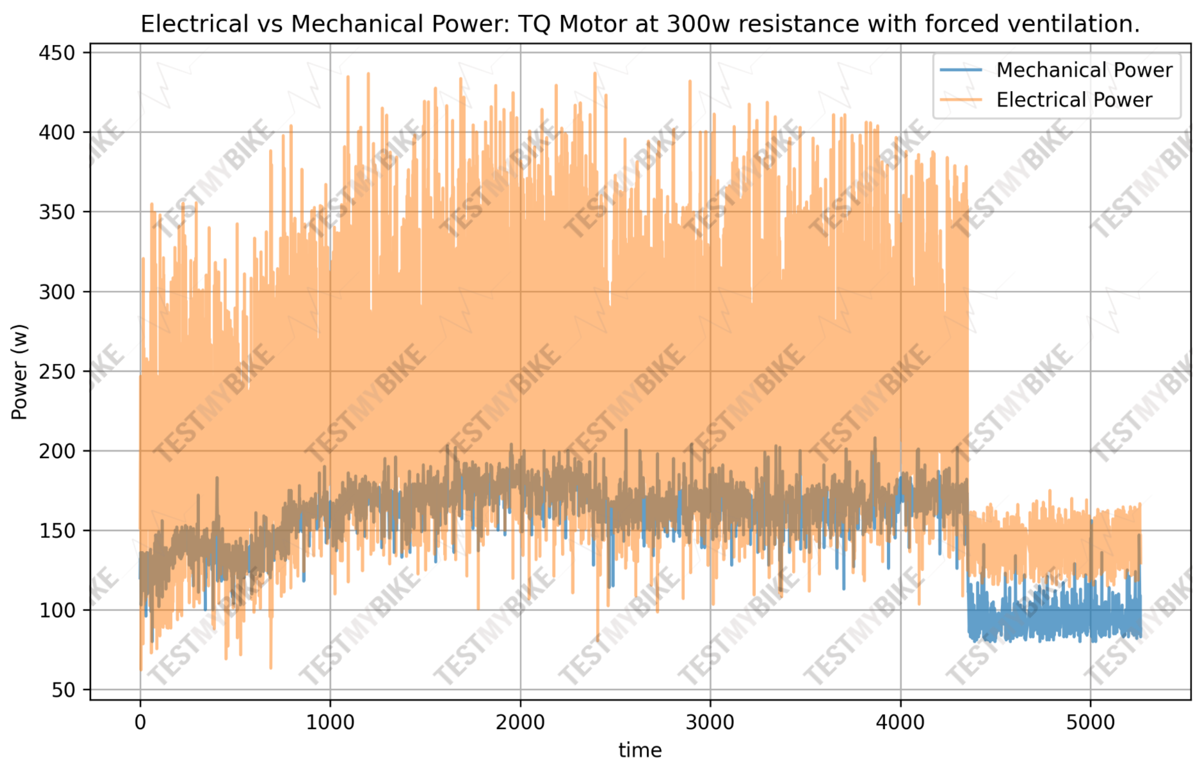
This test, conducted at a constant resistance of 400 watts, with a cadence of 80 RPM and forced ventilation, yielded surprising results. The first thing we observed was that the variation in power delivery is lower compared to the previous test (without forced ventilation at 300 watts of resistance). Additionally, we can observe how the power delivered by the TQ HPR50 motor decreases over time: The motor does not maintain a constant electric power output.

Our control data clearly shows that the TQ HPR50 motor is highly temperature-sensitive, and as the temperature increases, the system reduces power in a phenomenon known as "derating."

It is important to note that derating is a common protective mechanism in electric motors, including those used in electric bicycles like the TQ HPR50 motor. Under demanding conditions or high temperatures, derating helps protect the motor's electronic components, preventing premature failure. However, we have observed that in the case of the TQ motor unit, this derating seems to occur prematurely or more frequently than expected, indicating a possible limitation in its design or cooling system. This behavior could potentially impact the overall performance and efficiency of the motor, especially under high-demand conditions or during extended periods of use.

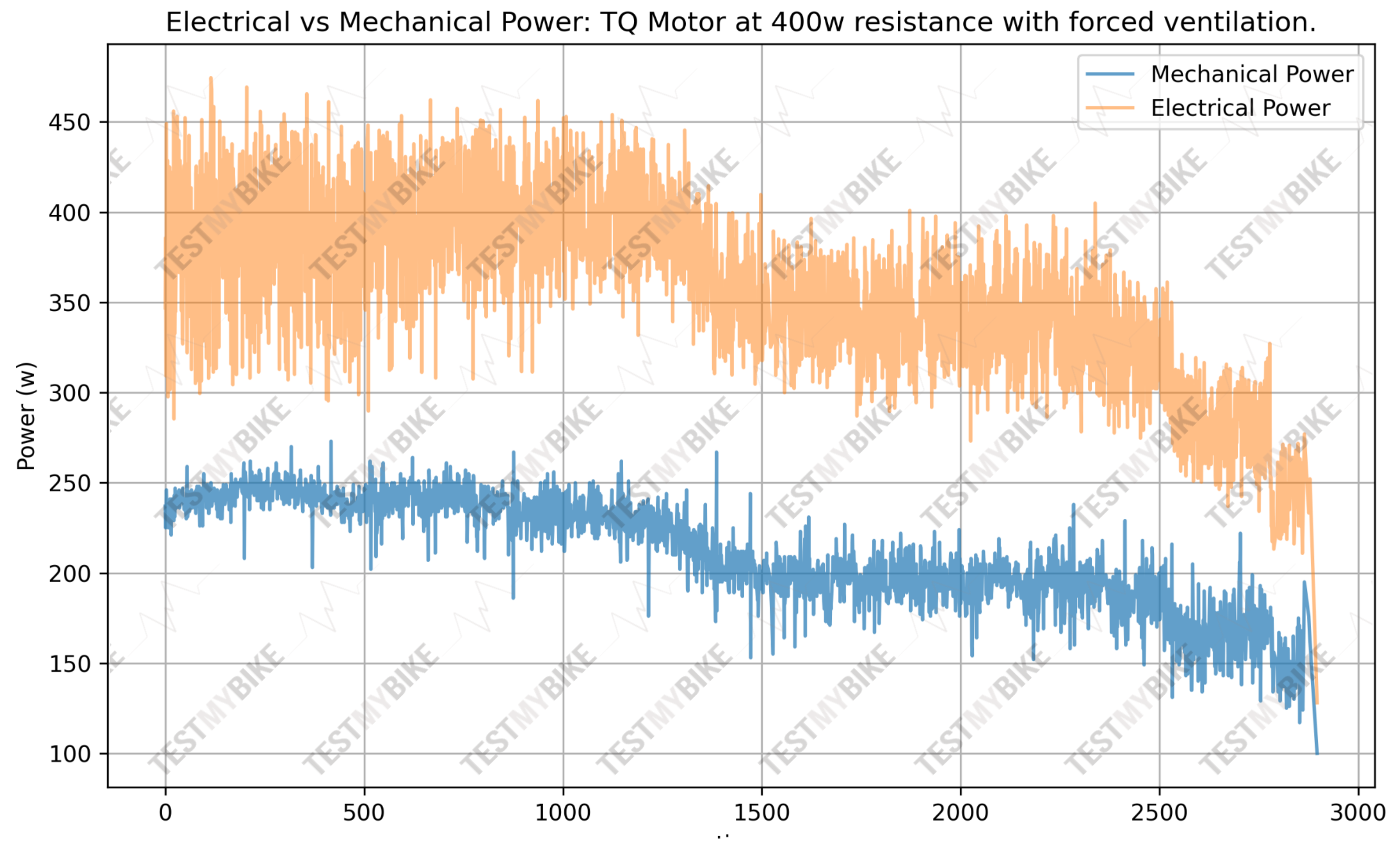
Given this behavior, we were interested in determining the mechanical power that the TQ HPR50 motor is capable of delivering compared to its electric power output, both at 300 watts of resistance and 400 watts.

3T est of Mechanical Power Vs Electric Power at 300 watts and 400 watts of resistance (until the battery is depleted). TQ HPR50.



In this long duration test at 300 watts of resistance with forced ventilation, we observed a significant discrepancy between the consumed electric power and the generated mechanical power. This suggests a possible loss of efficiency, which was surprising compared to what we typically observe in other types of motors that use planetary gear systems. These motors usually maintain a closer relationship between consumed electric power and generated mechanical power, resulting in higher efficiency. Our preliminary calculations indicate an efficiency loss between 10% and 14% compared to other motors using planetary gear systems.

We will delve deeper into this point in subsequent sections. Planetary gear motors tend to be more efficient. In our test, the TQ HPR50 motor showed a slight loss of efficiency, which implies higher energy consumption to produce the same amount of mechanical power. This efficiency loss can affect the range of the electric bicycle, reducing the distance that can be traveled on a single charge. It could also generate excess heat, which could explain the previously observed "derating."

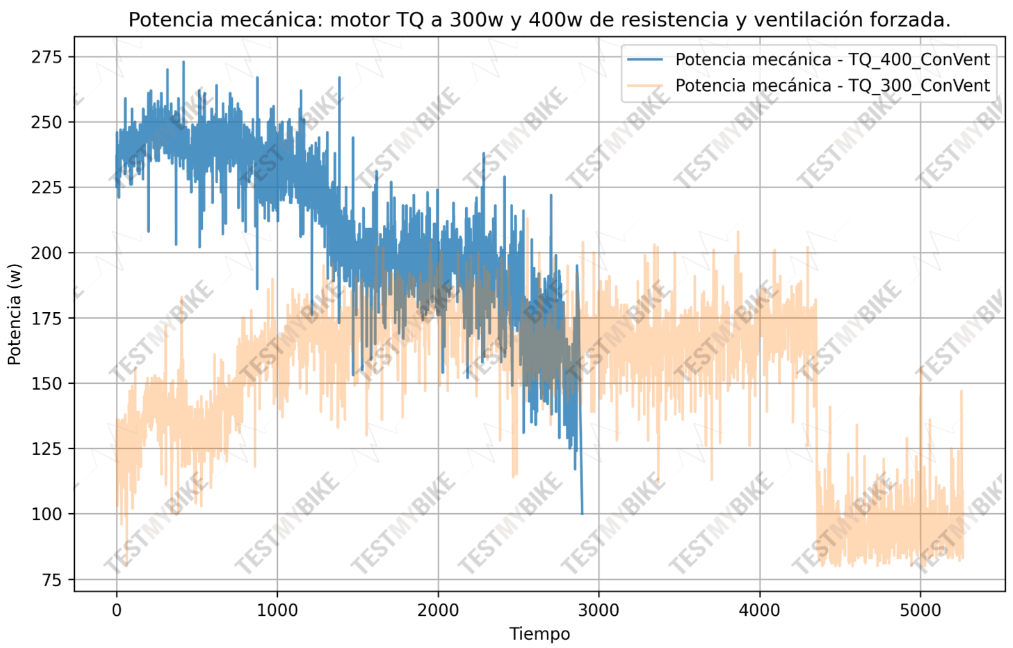


In our more demanding test at 400 watts of resistance, we again observed the same pattern of efficiency loss. In this case, the issue became even more critical due to the aforementioned derating. Undoubtedly, the TQ HPR50 motor seems to be more sensitive to temperature than the majority of motors we have previously analyzed at TMB.

Comparatively, the rest of the motors analyzed at TMB have shown better temperature management and more consistent efficiency. These motors maintain their output power and efficiency over time in our laboratory tests, without exhibiting the same derating issues we have observed in the TQ HPR50 motor.

To clarify these differences in range and mechanical power at 300 watts and 400 watts of resistance, we have decided to consolidate the mechanical powers into a single graph.

The TQ HPR50 motor can experience a loss of up to 15% in efficiency.



This comparison clearly illustrates that at higher resistance levels (simulated uphill), the TQ HPR50 motor offers higher mechanical power initially. However, as anticipated based on our previous test results, this initially higher power experiences a significant decrease due to derating. As a result, the system's range is considerably affected in the extreme 400-watt resistance test.

In the 300-watt resistance scenario, the TQ motor demonstrates, as expected, greater range since the motor is less strained, allowing for more effective temperature management and minimizing derating. However, as we increase the resistance to 400 watts, we can see that the motor initially delivers higher mechanical power, but this initial advantage diminishes as derating comes into effect, limiting the motor's power and reducing the range.

This observation is significant as it suggests that while the TQ motor may provide higher initial power under high-demand conditions, this advantage is quickly lost due to the system's protections triggered by increasing temperatures.

C. Comparison between TQ HPR-50 and Maxon Bikedrive Air Motor.

We believe it is appropriate to provide a more comprehensive understanding of our observations by comparing various tests of the TQ HPR-50 motor with a similar focus-oriented motor, the Maxon Bikedrive Air. We have chosen the Maxon motor for comparison as it represents the average behavior of the other motors tested.

Establishing a comparative framework with the Maxon motor will allow us to better understand the substantial differences we have observed between these two motors.

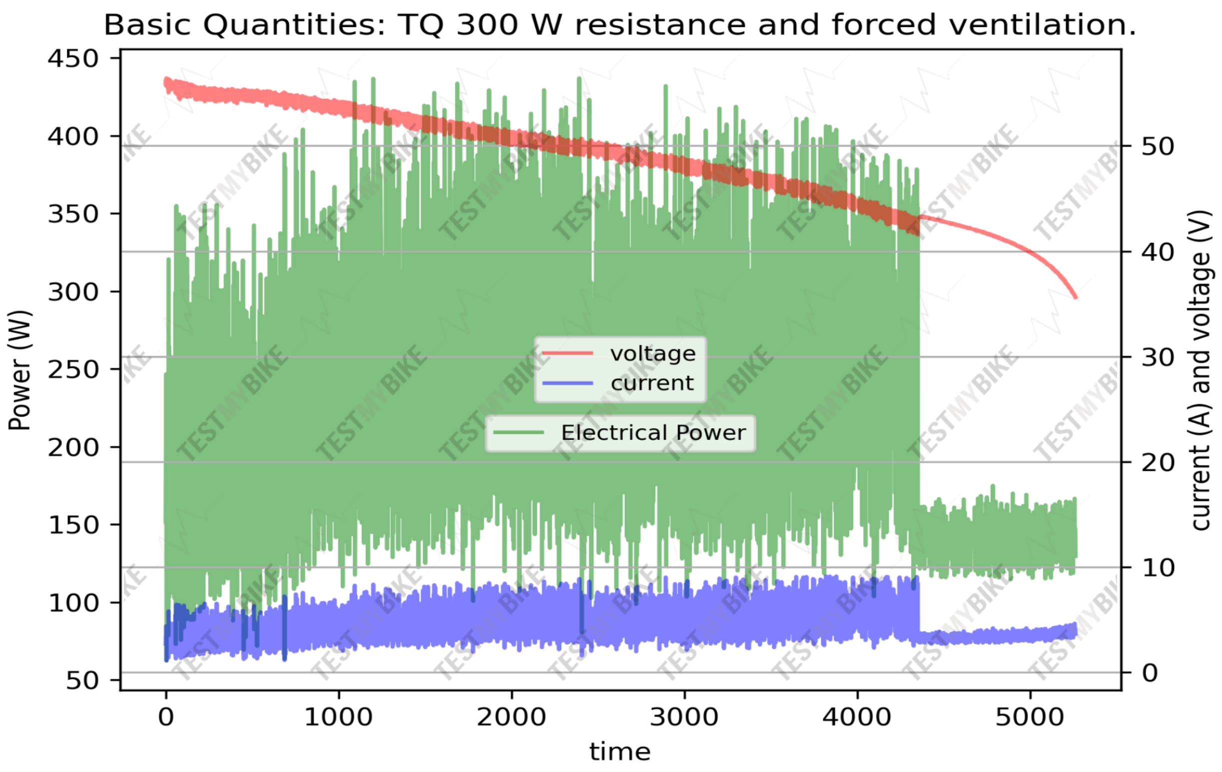
Specifically, we are interested in examining the disparities in temperature management, an aspect in which the TQ HPR-50 motor has shown difficulties in our tests.

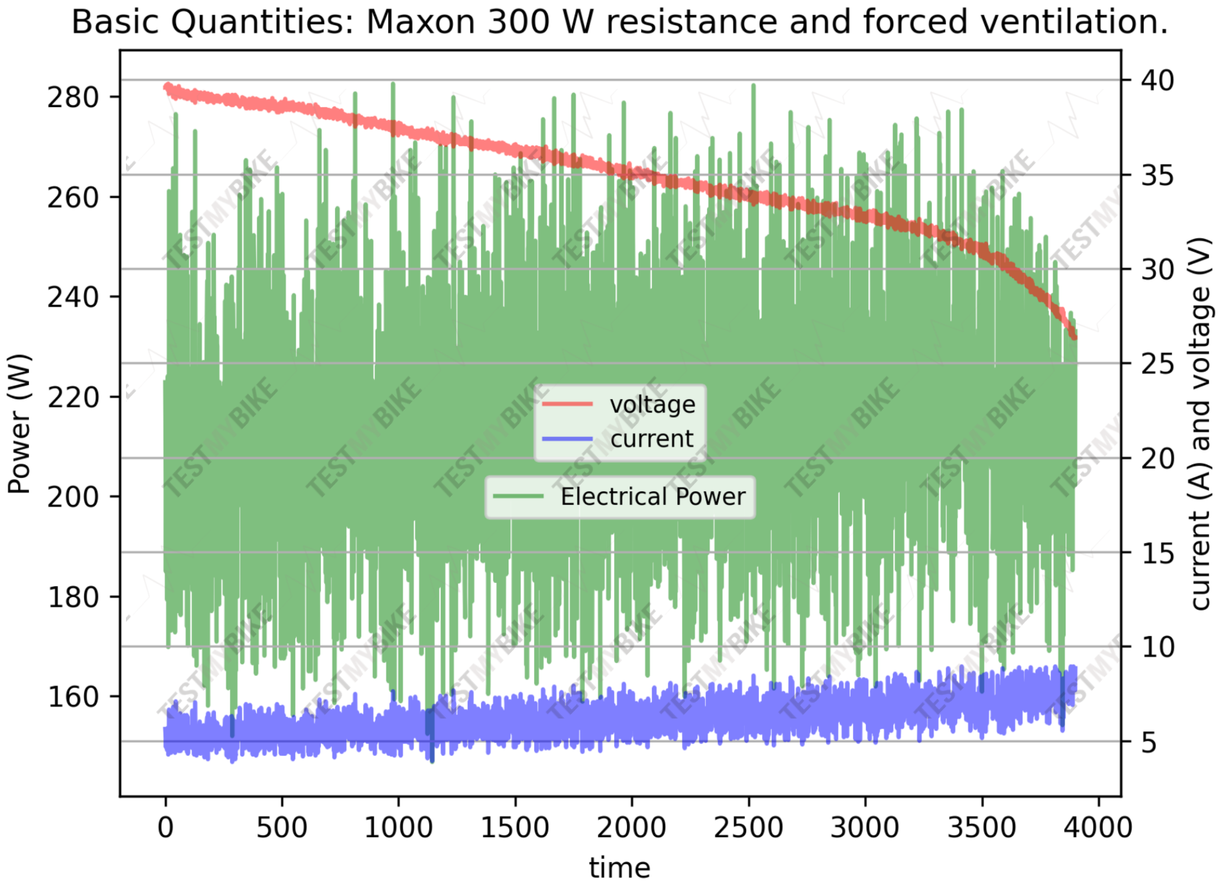
c.1 Long Duration Test at 300 watts of resistance: TQ HPR-50 vs. Maxon Bikedrive Air.

Before proceeding, we will present a table comparing the specifications of the TQ motor to the Maxon motor.

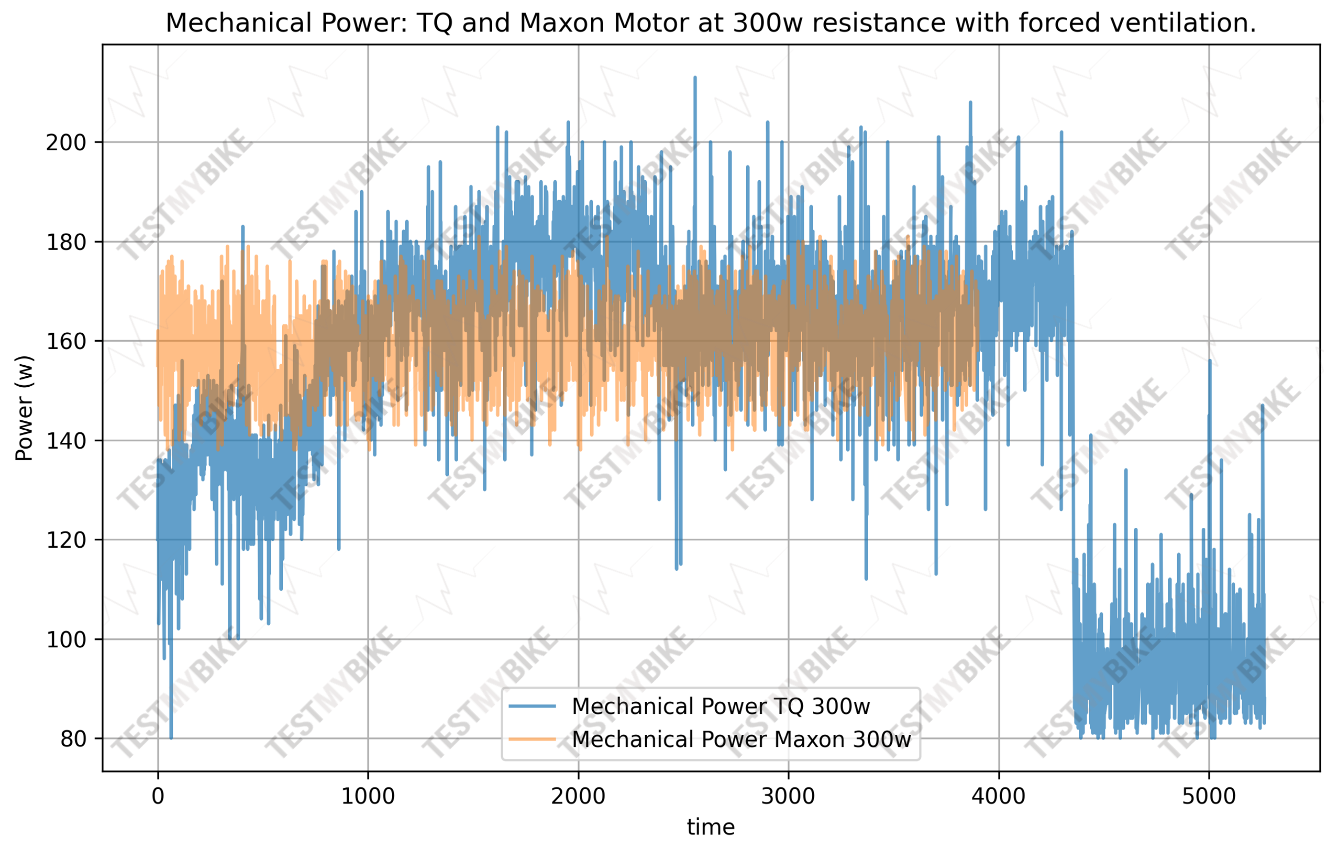
Especificación	Maxon Bikedrive Air	TQ HPR 50
Par máximo	40Nm	50Nm
Potencia continua nominal	250W	250W
Potencia máxima	250W	300W
Máxima cadencia soportada	115 Rpm	140 Rpm
Clase de protección	No especificado	IP67
Temperatura de trabajo	No especificado	-5ºC a 40ºC
Temperatura de almacenamiento	No especificado	0ºC a 40ºC
Longitud del eje del pedalier (Factor Q)	155mm	135mm
Peso del motor	1.9kg	1.850g
Capacidad de la batería	250Wh	360Wh
Voltaje nominal de la batería	36V	50.4V
Capacidad nominal de la batería	6.9Ah	6.8Ah
Energía nominal de la batería	250Wh	360Wh
Dimensiones de la batería	No especificado	48 x 63.5 x 370 mm
Peso de la batería	1.4kg	1.835g
Capacidad del Range Extender	250Wh	160Wh
Voltaje nominal del Range Extender	36V	50.4V
Capacidad nominal del Range Extender	6.9Ah	2.8Ah

The first thing we notice is that the TQ motor has higher electrical power compared to the Maxon, and a very similar range. This observation is made if we disregard the last part of the TQ test, where this motor fails to maintain its assistance consistently in turbo mode and automatically switches to ECO mode.





However, when examining the mechanical power generated by both motors, we find that the Maxon motor, despite consuming less electrical power, produces practically the same mechanical power as the TQ motor. This is another indication that points to lower efficiency of the TQ motor compared to the Maxon motor.

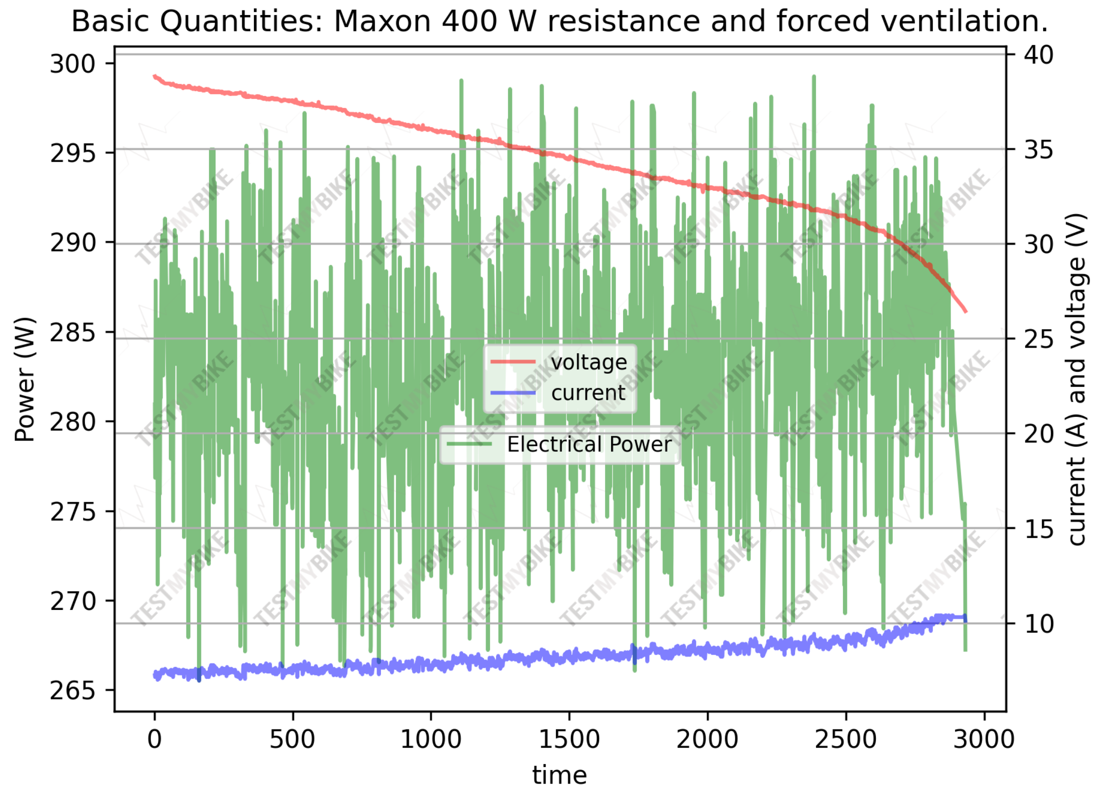


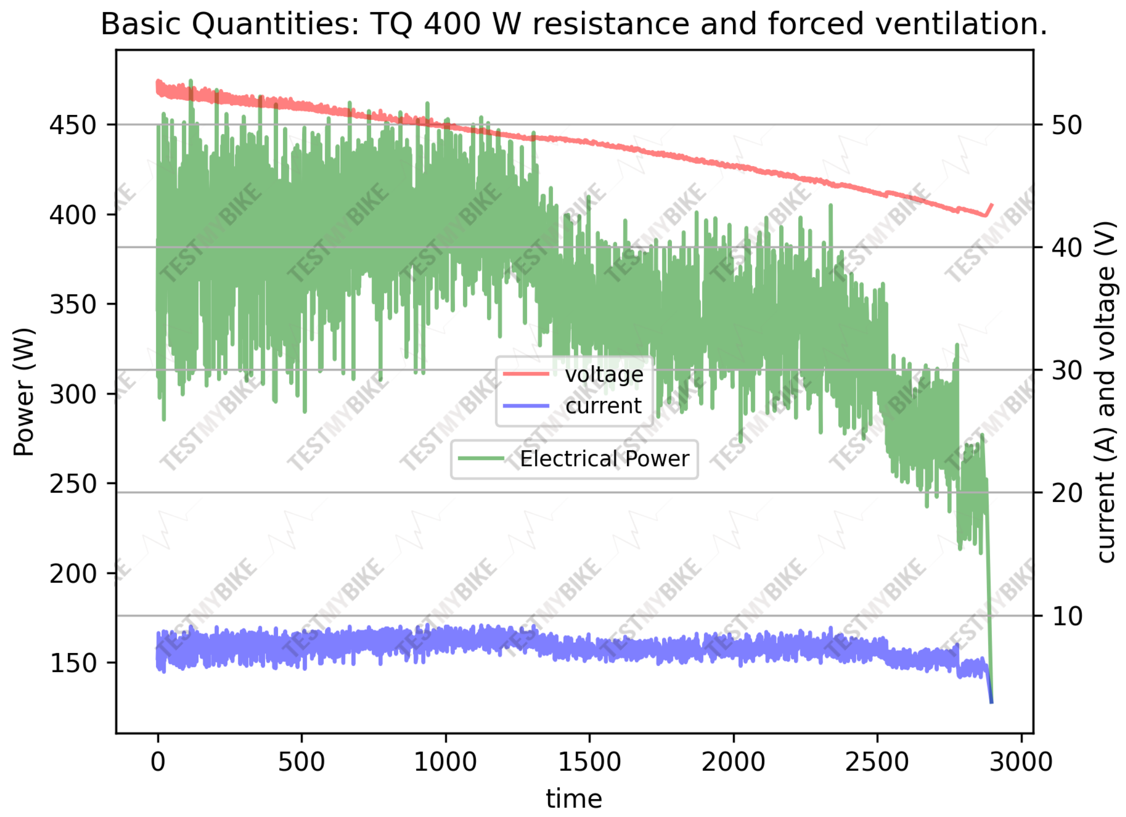
This is particularly notable since the mechanical power is ultimately what the cyclist experiences during the use of the electric bicycle. Although the TQ motor may boast higher electrical power, if this additional performance does not translate into higher mechanical power, the practical advantage for the user is questionable. In fact, it could be argued that the TQ motor is using more energy to achieve the same result as the Maxon motor, which raises questions about its efficiency.

Therefore, despite the higher electrical power of the TQ motor, our results indicate that it does not necessarily provide better performance in terms of mechanical power compared to the Maxon motor.

c.2 Long-duration test at 400W resistance: TQ HPR-50 vs. Maxon.

In this test, we will examine how both motors perform under 400W resistance conditions.

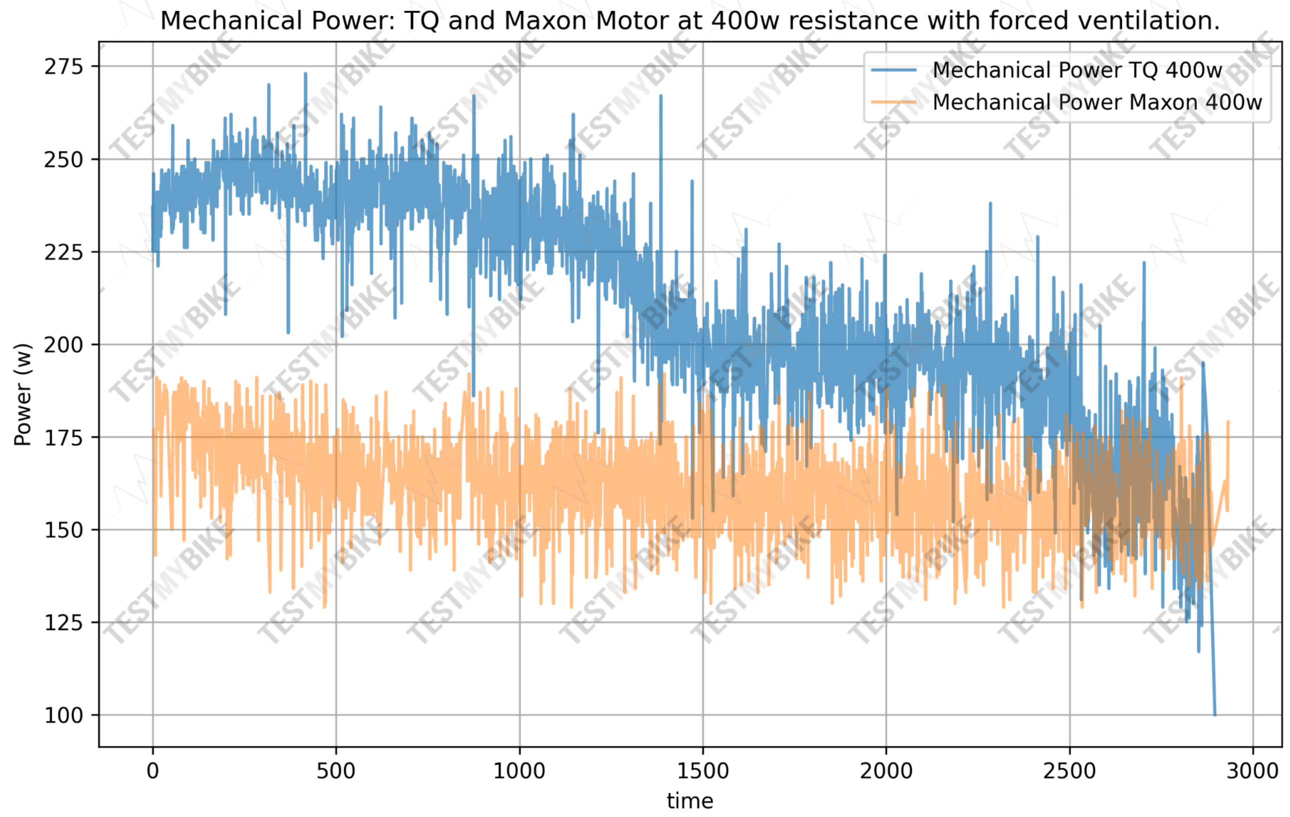




The Maxon motor, although less powerful than the TQ, maintains its maximum power constant throughout the test without experiencing derating. This emphasizes the TQ's higher sensitivity to temperature compared to the Maxon.

Regarding range, we find that it is very similar in both motors during this test.

Now, if we turn our attention to mechanical power, we do observe that despite the derating suffered by the TQ motor, it offers more mechanical power than the Maxon. However, it is important to note that due to its inability to maintain constant mechanical power, the TQ motor does not provide a uniform power curve.



This point is crucial, and we need to highlight two aspects: first, although the TQ motor may initially provide more mechanical power than the Maxon, this advantage diminishes over time; second, the inconsistency in power delivery of the TQ HPR50 motor can result in a less satisfactory user experience.

In contrast, the Maxon, although less powerful, offers more consistent mechanical power, which could be preferred by many users. This comparison highlights that when choosing a motor, not only its maximum power should be considered but also its ability to maintain it consistently and efficiently over time.

Conclusions

In long-duration tests at 300w and 400w of resistance, the TQ HPR50 motor initially showed superior performance compared to the Maxon motor. However, this performance diminished over time due to derating (self-protection).

In our testing method, even though the TQ HPR50 can offer more mechanical power initially, there is a reduction in power output over time. On the other hand, the Maxon offers initially lower but more consistent and uniform performance, providing its maximum power throughout the test.

We noticed that the TQ motor offers around 15% less efficiency than the motors analyzed so far by TMB.

From Test My Bike, looking at pure laboratory data, without considering that its integration is ideal and its low noise level, we can conclude that the TQ HPR50 motor requires a maximum electrical power of 400 watts and generates a maximum mechanical power of 320 watts. Likewise, the TQ HPR50 motor obtains its best performance between 60 and 130 RPM (cyclist's cadence).

TESTMYBIKE

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