AMD RYZEN™ PRO 5000 SERIES MOBILE PROCESSORS: UNCOMPROMISING PERFORMANCE AND BATTERY LIFE

It's probably no surprise that most surveys show battery life is either at, or near, top of the list of factors influencing notebook purchasing decisions. The longer we can work unplugged, the more freedom we feel, and the more dependable our experiences will be. And, of course, we want more and more and more. Not long ago, eight hours was the gold standard, then ten...and that number keeps rising. As our tasks for both home and office get more power-intensive, from streaming to data-intense calculation, optimizing for power efficiency gets even more difficult. How can we build laptops that can keep up with evolving end-user demands?

ONGOING, EVOLVING EXPECTATIONS

The fact is that as soon as that next goal is reached, the bar will have already been raised. The OS and the workloads will continue to demand more performance (which equates to more power demands on the system), while battery capacities are trending smaller to optimize for the thinnest and lightest ultra-portable laptops.

Also, while traditional TFT-LCD displays now have very low-power models available, newer OLED displays are generally much higher-power consumers, at least for early models. Resolution plays a part, too: the higher the pixel count, the more work required from the processor and memory, and it is not an insignificant increase in performance demand.

HOW WE SOLVE IT: THE AMD APPROACH TO BATTERY LIFE

AMD is solving the battery life dilemma (power vs. performance) by optimizing power management and battery life for a variety of diverse workloads rather than a precise focus on one specific use case scenario. Since any particular user's experience with battery life is unique to how they use their laptop, our goal must be to deliver best-in-class battery life for a large variety of use case scenarios.

This must be accomplished regardless of how the laptop is used, or how that usage changes across a single day or even longer periods of time. The end goal is an AMD strategy focused on best-in-class. This requires us to work closely with our OEM partners in order to ensure their AMD platforms always top the leaderboard in battery life.

BALANCING PERFORMANCE AND POWER FOR OPTIMAL BATTERY LIFE

While designing and developing desktop and mobile processors are both extremely challenging, the complexity of power management is not. The primary low-power metric for desktop PCs is compliance with regulatory standards such as Energy Star and California Energy Commission. While building for these requirements isn't easy, engineers only have to optimize for the easiest-to-achieve low idle power mode.

A laptop/mobile processor is significantly more complex when it comes to balancing performance versus power. Speed is still absolutely required, but much more attention must be paid to power consumption for not just the processor itself, but all adjacent system components. This requires a sharper focus on performance per watt, and more advanced features and optimizations come into play. This careful balance between performance and battery life is especially evident in the OS Performance Power Slider. We'll look at that in a bit.

WHEN IT COMES TO USER EXPERIENCE, RESPONSIVENESS > RAW PERFORMANCE

Whether you are talking about core CPU workloads or graphics tasks, good responsiveness is different than raw performance. Responsiveness is about how snappy the system feels as the user navigates within windows, browses files, uses productivity apps, and

more. Good responsiveness helps to ensure an experience that feels as seamless and immersive as possible. This is a meaningful performance optimization.

For the typical business/corporate user, this responsiveness can often be much more important than raw performance. So a laptop that delivers best-in-class battery life that isn't crisp and responsive will fail to meet user expectations and basic enterprise requirements for a best-in-class user experience.

HOW AMD DOES IT BETTER

This is what AMD optimizes for: best-in-class battery life that still feels responsive and snappy while on DC power. AMD delivers significant architectural enhancements in "Zen 3" that improve the pure performance of AMD Ryzen™ PRO 5000 series mobile processors in AC and DC power modes, but we'll stay focused on responsiveness here.

Key "Zen 3" improvements include:

- Collaborative Processor Performance Control (CPPC) enables up to 20x faster selection of the proper clock speed when the OS calls for higher activity. We'll discuss this more later.
- Unified cache structure means that all of the larger L3 cache is equally accessible to all cores, significantly improving cache latency. More "Zen 3" enhancements below.

MEASURING RESPONSIVENESS

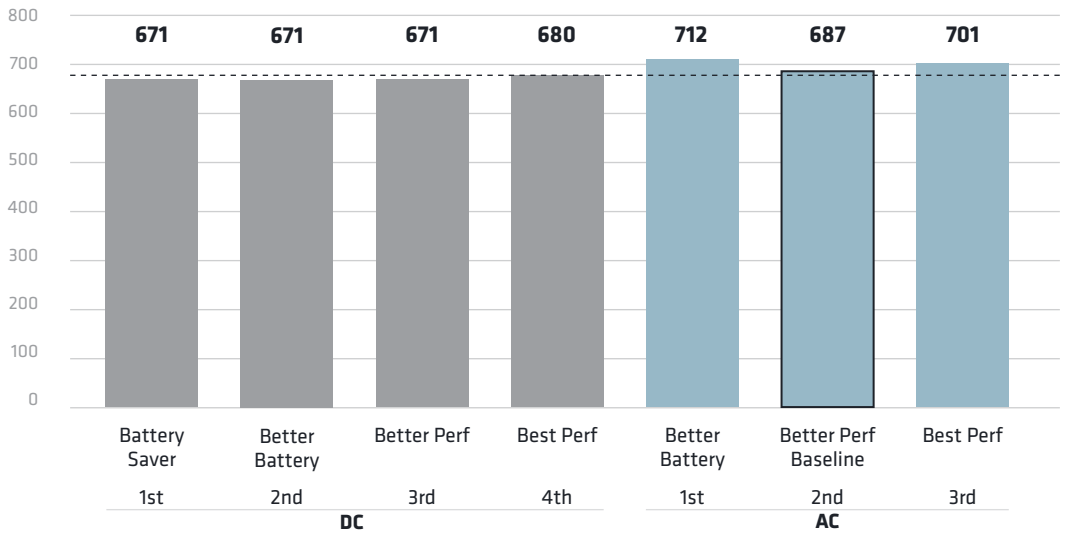
As measured by Microsoft's own Windows experience responsiveness metrics, AMD Ryzen™ PRO 5000 series mobile processors show essentially an unwavering signature of snappy responsiveness in AC as well as DC power source modes. To the end-user this means you always get the same great experience, even when on battery.

Windows Responsiveness Metrics ***Figure 1***

WINDOWS OS RESPONSIVENESS METRICS		DC (ms)	AC (ms)
Individual - Boot Performance Fast Startup	BIOS_Initialization_Duration(average)	20.0	19.4
	Total_Boot_[Excluding_BIOS](average)	5.6	4.9
	Total_Shutdown_Time(average)	9.0	7.1
Individual - Boot Performance Full Boot	BIOS_Initialization_Duration	21.9	20.7
	Shutdown_Duration	6.8	6.7
	Total_Boot_[Excluding_BIOS]	7.9	7.4
Individual - Hibernate Performance	BIOS_Initialization_Duration(average)	19.3	18.3
	Overall_Suspend_Time(average)	7.2	6.2
	Total_Resume_[Excluding_BIOS](average)	4.8	5.4
Modern Standby	Entry (ms)	5727	5711
	Exit (ms)	680	687

The following chart shows Modern Standby Exit time across all seven OS Power Slider settings, often considered to be the most important of all the OS metrics, since it is typically experienced much more frequently than all other metrics combined.

Modern Standby Exit Time (milliseconds) with AMD Ryzen 7 PRO 5850U *Figure 2*



As you can see in *Figure 2*, regardless of which OS Power Slider Position, there will be no perceivable difference in the actual user experience.

BIG-PICTURE PERFORMANCE: THE BLENDED WORKLOAD APPROACH

As mentioned earlier, every user will have a different battery life experience, even on the same laptop, determined by how they configure key variables. Here are a few examples of critical variables:

- The first and most important is display brightness; a user demanding the maximum display brightness can cut battery life by 50% in some cases.
- Another critical variable can be the keyboard backlight, a popular feature on business laptops. AMD has measured system power increases as high as 2W, potentially doubling the system idle power. This is another opportunity to optimize.
- Also, we must mention the OS Performance Power Slider position, a setting of DC#4 (i.e., Best Performance) does deliver AC-like Performance, but at the cost of almost AC-like power consumption; avoid this setting for the best battery life experience. Position DC#2 (i.e., Better Battery) provides an optimal battery life experience with a minimal performance compromise.

As almost every aspect of the system is a contributing factor to system power and therefore battery life, any battery life claim requires a long list of qualifiers in order to be reliably reproducible.

Today, it seems that every reviewer, IT leader, and even users have their own special list of conditions and workloads that define their expectations on battery life. This is understandable, but meaningful measurement and comparison relies on conditions and procedures that can be precisely replicated for each test.

Adherence to these objective measures enables relevant "apples to apples" evaluation of performance, responsiveness, and battery life from platform to platform, or config to config on the same platform.

For business laptops, OEMs will primarily utilize a license-required industry-standard blended application-based battery life workload by BAPCo, called MobileMark® 2018. It specifies and controls all platform contributing factors and therefore is repeatable and a good means to compare different makes and models of laptops, as well as different configurations of the same laptop model. While AMD does focus on power optimization of this industry-standard blended workload, an even broader workload approach also helps ensure that no matter the task or expectation, users will get an AMD best-in-class battery life experience.

SIMPLE CAN BE DECEPTIVE

End-users and reviewers often resort to a simpler approach to measuring battery life, such as playing a video in a loop, either streamed or from local storage. While this is an important use case, it is rather one-dimensional.

It is very important to ensure that 100% of all testing conditions are matched from system to system when comparing. Also, note that industry manufacturers typically do not utilize streaming content for battery life claims exactly because the results can be so highly variable. They stick with highly repeatable and legally defensible workloads for their battery life measures and subsequent claims.

THE OS SLIDER AND THE AMD RYZEN™ PRO 5000 SERIES MOBILE PROCESSOR

The AMD Ryzen™ PRO 5000 series has been optimized for a full OS Performance Power Slider implementation. AMD's optimization strategy, per slider position, is consistent with the OS documentation. There are seven OS Power Slider positions, DC and AC, as mentioned above, and as defined in ***Figure 3***.

All Seven OS Power Slider Positions ***Figure 3***

DC				AC		
1st	**2nd**	**3rd**	**4th**	**1st**	**2nd**	**3rd**
Battery Saver	Better Battery	Better Perf DEFAULT	Best Performance	Better Battery	Better Perf DEFAULT	Best Performance

Of course, for battery life, we are concerned with only the four DC Slider positions. AMD's performance and power strategy per position is summarized as follows:

DC OS Slider Positions ***Figure 4***

DC OS SLIDER POSITION			
DC-1st	**DC-2nd**	**DC-3rd**	**DC-4th**
Battery Saver	**Better Battery**	**Better Performance**	**Best Performance**
Dims the display brightness, other OS directed. OEMs do not use, and not possible to select as default.	Typically utilized for battery life measures and claims at the expense of performance.	OS, AMD, and most OEMs default for DC. Provides most optimal DC perf/ power balance.	Highest performance in DC. AC-like perf at the expense of battery life. Typically, single-digit % redux from AC.

So, while OEMs will typically ship as default DC Slider position #3, they will measure and make final battery life claims with DC Slider position #2. AMD has optimized the slider positions likewise. While AMD recommends that all platforms ship with the AMD defaults, the definition and performance/power balance of each slider position is owned by the OEMs.

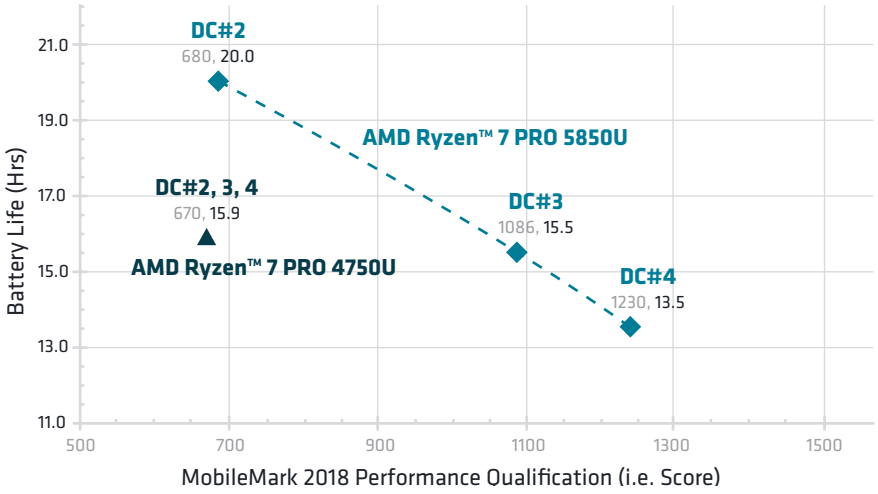
As such, AMD works with the OEMs to modify the performance/power optimizations per slider position as an OEM desires on a platform-by-platform basis. An end-user can easily change those optimization balance points on-the-fly via the OS Performance Power Slider UI as needed.

USER EXPERIENCE AND BATTERY LIFE SIGNATURE ACROSS THE OS PERFORMANCE POWER SLIDER POSITIONS

The AMD strategy is to provide the end-user with dynamic control of the performance/power (i.e. battery life) balance via the OS Performance Power Slider. AMD OS optimizations are designed to allow all users to select whatever balance point they need. This includes the book-ends of maximum performance (i.e. DC#4 Best Performance) and maximum battery life (i.e. DC#2 Better Battery), and a nice middle ground with DC#3 (i.e. Better Performance, also the OS and AMD default).

AMD labs have always been focused on study and analysis that ultimately delivers innovations that bring performance and user experience improvements from generation to generation. AMD Ryzen™ PRO 5000 series mobile processors deliver a significant advantage over the prior generation. Looking at the OS Performance Power Slider setting to setting we can see that while the AMD Ryzen™ PRO 4000 series mobile processors delivered long battery life there was no differentiation from OS Slider position to position. AMD Ryzen™ PRO 5000 series mobile processors not only significantly improve that best battery life, but also deliver significant performance and power balance point differentiation across the OS slider positions, providing the end user with that dynamic control as previously mentioned.

AMD Ryzen™ PRO Generational Compare of Battery Life and Performance[1,2] ***Figure 5***



Ryzen PRO processor generational compare of battery life and performance. Note that the user has complete battery life and performance flexibility and control with the AMD Ryzen™ PRO 5000 series processor. As compared to the AMD Ryzen™ 7 PRO 4750U processor, the AMD Ryzen™ 7 PRO 5850U processor user can select:

1. *DC#2 at similar performance with up to 26% battery life improvement,*
2. *DC#3 at similar battery life with a up to 62% Performance improvement, or*
3. *DC#4 with up to a 15% battery life compromise delivering up to an 84% performance improvement*

[1]Testing by AMD Labs using the MobileMark® 2018 benchmark test to measure the battery life and performance of a Ryzen™ 7PRO 5850U processor vs. a Ryzen™ 7 PRO 4750U processor. MM18 scores for Ryzen™ 7PRO 5850U at data points DC#3 and DC#4 and for Ryzen™ 7 PRO 4750U at data points DC#2 and DC#4 are estimates.
[2]Windows 10 MobileMark® 2018 battery life will vary depending on various factors including product model, configuration, loaded applications, features, use, wireless functionality, battery capacity, and power management settings.

SOLVING FOR SECURITY VS. PERFORMANCE

Security features are a key requirement for enterprise productivity, and always a critical part of AMD's design philosophy. This continues to be true for the AMD Ryzen™ PRO 5000 series, where we are improving security features with the most negligible impact on performance and power. And this commitment to security leadership isn't just about today—AMD security capabilities and unique features ensures maximum security robustness and power efficiency in the years to come.

The bottom line will always be minimum compromise, maximum user experience.

Evidence of this commitment is a growing list of much-sought-after AMD silicon security features, all with no power or battery life penalty, including one new addition to the Ryzen™ PRO 5000 series.

- Transparent Secure Memory Encryption (TSME, also known as AMD Memory Guard)
- Indirect Branch Control (IBC)
- Guest Mode Execute Trap (GMET)
- User Mode Instruction Prevention (UMIP)
- AMD Shadow Stack (new for Ryzen™ PRO 5000 series)

SYSTEM POWER AND POWER DELIVERY (DC-DC EFFICIENCY)

Another area where AMD has achieved significant generational improvements is in platform power delivery to the processor. As one of the larger power consumers in a laptop system, careful and precise management of power delivery to the processor can save hundreds of mW of power in the form of DC-to-DC efficiency, and for essentially no compromises.

DC-DC loss in a platform is often glossed over and misunderstood as a significant power consumer in a laptop. Careful power delivery management within the processor as well as the board-level power delivery sub-systems can make the difference between just okay battery life and best-in-class experience.

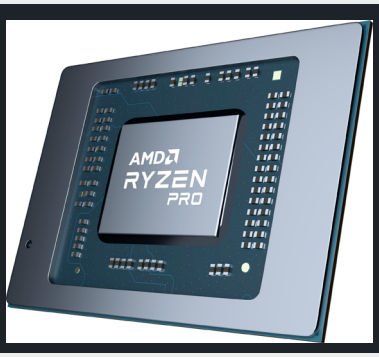
THE NUMBERS UP CLOSE

We can also look up close, across all major system components, to see the system power signature. ***Figures 6 and 7*** show two different workloads, Windows Idle and the previously discussed industry standard blended workload used by commercial platforms.

- In each case, notice the two highest power consumers are the display and the processor. Focusing on the display a little more, changing the workload by increasing the brightness to 100% (~400 nits as opposed to the set point of 150 nits) can significantly increase that component power.
- Likewise, disabling the AMD display power feature Vari-Bright would also have a significant negative effect on battery life. Vari-Bright is an AMD proprietary power-saving feature that works with all TFT-LCD displays.
- Most important is the display model selected for the platform; a standard TFT-LCD display at FHD resolution can be found with the power signature shown in ***Figure 6*** or even lower.
- Additionally, more expensive panels touting high refresh rates, special privacy features, and high pixel counts (e.g., UHD) will have higher power consumption. Finally, while OLED displays may be visually superior, they also come with a superior price tag and higher power consumption.

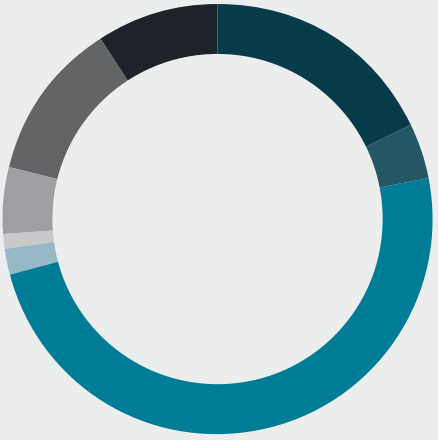
Reading and replying to email is not much more of a system power load as compared to Windows Idle shown above. Also note that regardless of the display panel make/model or even resolution, there will always be a lower display power consumed by dialing down the brightness, so user preferences on the display brightness setting is a significant contributing factor of battery life. Low system power, and therefore high battery life, are fragile.

Many users might not understand exactly how the choices they make impact battery life. Even if they know, they can have good intentions that quickly fade. They may start the day trying to preserve battery life, but soon enough they have videos streaming, 30-40 tabs open across multiple browsers, display brightness at maximum, and multiple apps with many processes running.



Ryzen PRO 15W Windows Idle Average System Power Breakdown

Figure 6



9%	Rest of System
12%	DC-DC Loss
5%	System Power Delivery
1%	WLAN/BT WiFi6
2%	M2.SSD 512GB PCIe Gen3
18%	Ryzen PRO 5850U Processor
4%	Memory 2X4GB DDR4
49%	13" LCD-TFT Display

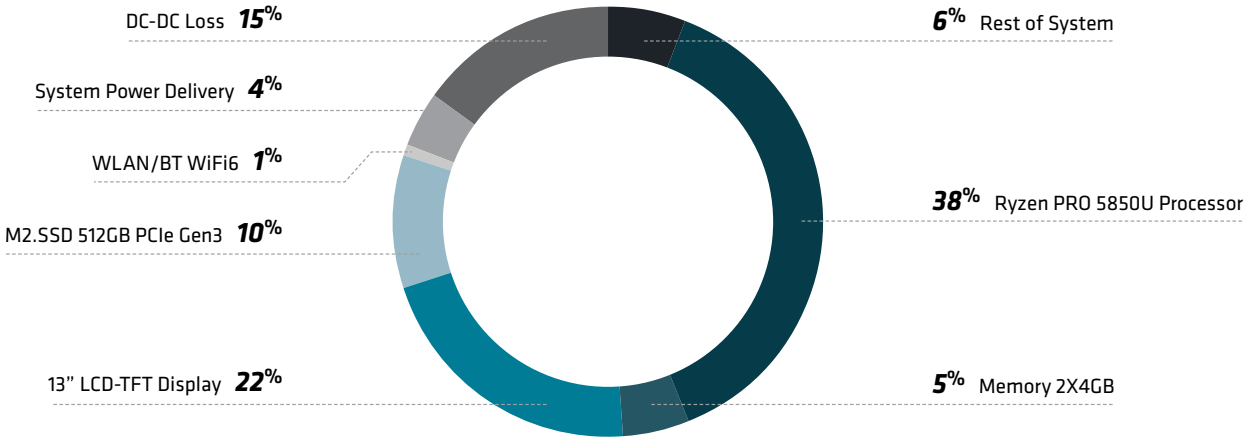
The above user scenario is not reflected in the above Windows Idle chart. Ultimately, no matter how a processor is designed and optimized, maximizing battery life is no accident – user behavior makes all the difference.

And below we have a higher activity workload with the system component power breakdown. This is that industry-standard blended workload used by commercial platforms ~2X higher system power than for Idle:

- The processor consuming almost 4.5X
- Display power that is actually a bit lower
- DC-DC loss as the 3rd-highest power consumer

Note that it is impossible to optimize the system power without focusing on those top three or four power consumers.

Ryzen PRO 15W Industry Standard Blended Workload Average System Power Breakdown ***Figure 7***



To solve for this, AMD has focused on the entire business platform when developing the Ryzen PRO processor. Since platform system power is cumulative, not just the top three or four consumers, every component adds to the total. **Overlooking system component power consumers will invariably mean those components are limiting the best possible battery life.**

THERMAL IMPACTS ON BATTERY LIFE

Another clue about specific user preferences affecting battery life is the laptop thermal solution – more specifically, the fan. Even in the above scenario with system power in the ~3W range, the system fan should be silent and off. Typically, the processor power needs to be in the 3W range just for the fan itself to start to spin, consume some power, and make some noise.

So, if a user's fan is making noise, they have way too much work occurring for an optimal battery life experience. Whether it is 50 browser tabs open or just a few processes doing some heavy work, the workload is already too high for a battery-life optimized user experience.

COMPARE AND CONTRAST: AMD RYZEN™ PRO 4000 VS. 5000 SERIES BATTERY LIFE

In the final analysis, it is the total system power that really matters for battery life, not merely APU – or rather, processor power. Battery capacity is just as important, and so higher is always better.

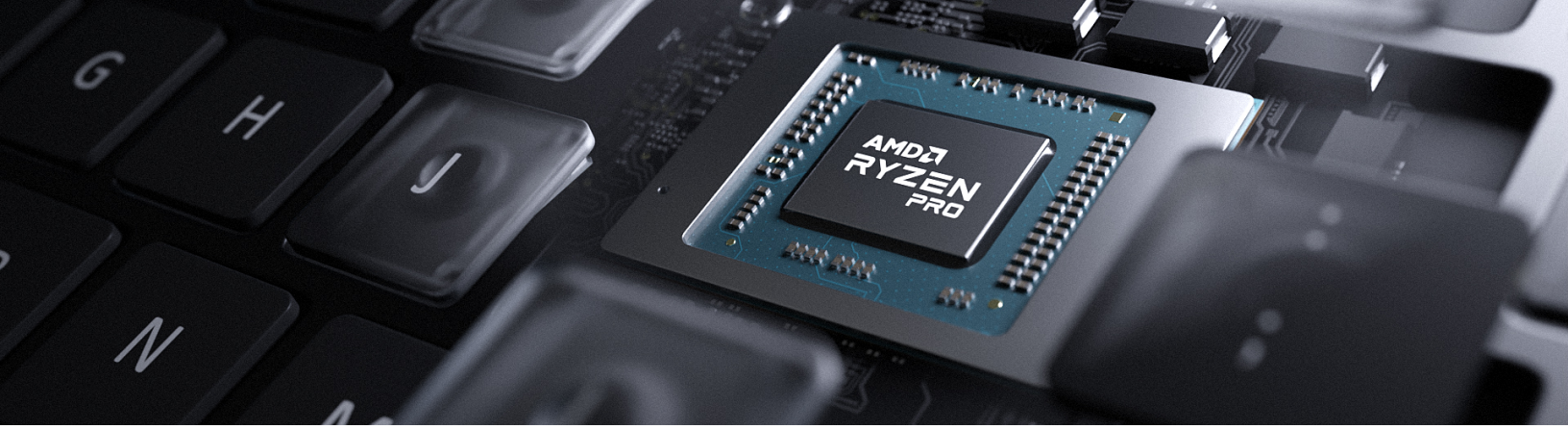
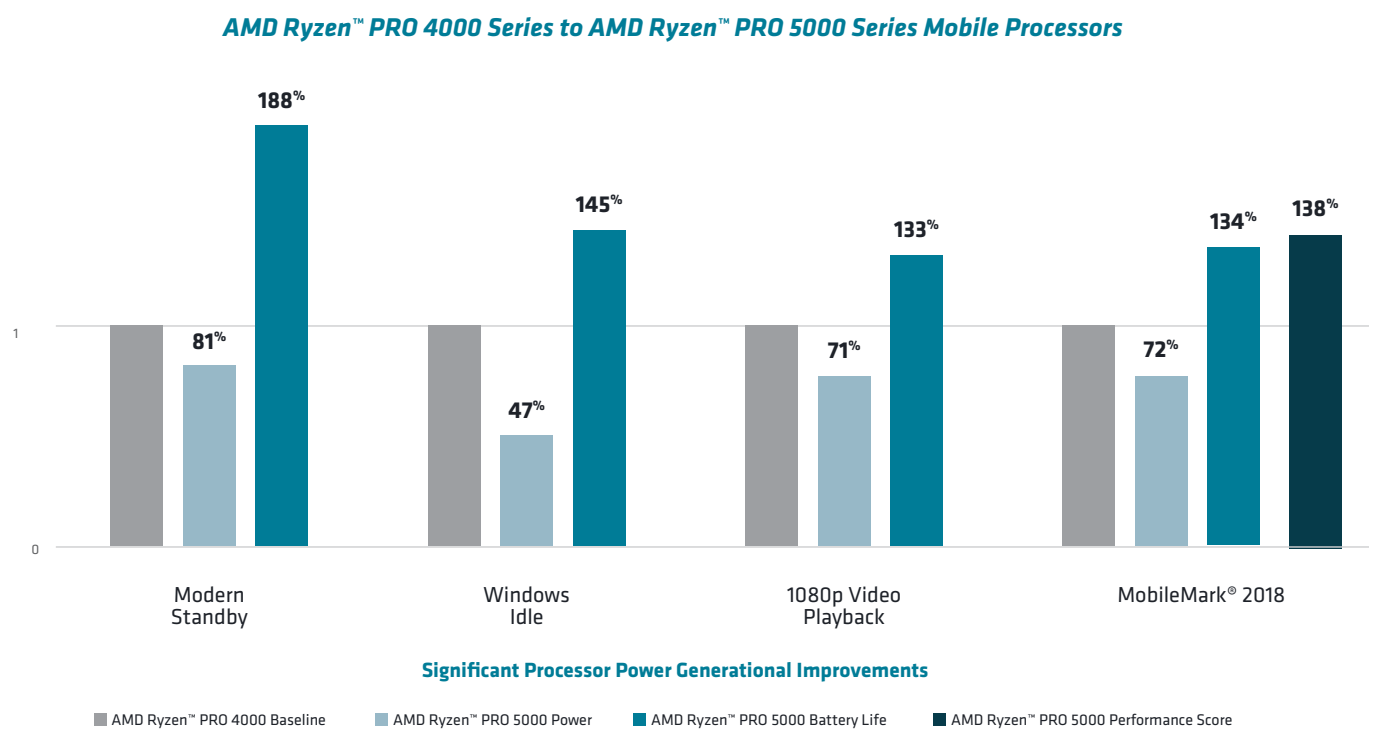


Figure 8 highlights some of the processor power and system battery life improvements from "Zen 2" based Ryzen PRO 4000 series mobile processors to the newest "Zen 3" based Ryzen PRO 5000 series mobile processors.

Power, Battery Life, and Performance Improvements *Figure 8*



So how did AMD's "Zen 3" Ryzen PRO 5000 significantly improve power and performance over the previous generation?

Here are the highlights:

- Per-core on-chip power management allows each core to operate at an optimal voltage and frequency, as opposed to all cores being tied together, as was the case for Ryzen PRO 4000 series.
- CPPC handshaking between the processor and the OS optimizes clocks in all operating conditions, lowers system power/keeps temps lower, and at the same time improves performance, thereby improving performance per watt.
- DC-DC efficiency is improved, minimizing this significant system power consumer.
- Memory power optimizations (also known as Memory PHY Deep Power State) on the Ryzen PRO 5000 series allow lower voltages and a 20% savings on memory power.
- Our 7nm manufacturing process continues to be refined and optimized.

As our next generation of mobile processors is in development now, our early measure-based projections indicate yet another significant improvement in power reduction, performance improvements, and performance-per-watt gains.

WHAT DO THE OEMs REPORT ON THEIR BUSINESS PLATFORM BATTERY LIFE CLAIMS?

Business platforms will be relying on the MobileMark® 2018 metric almost exclusively for their 2021 platform battery life claims. Some may include Modern Standby, and very few if any will list any type of video playback, or even MobileMark® 2014.

From a battery life standpoint, MobileMark® 2018 reports significantly less battery life as compared to MobileMark® 2014. While the platform will deliver the same real-world battery life to a user regardless of what any metric may report, the fact is that the MobileMark® 2018 reporting will be much closer to a user's real-world experience.

The improved relevance of MobileMark® 2018 is due to the higher power consumption in general, and the added suites of Creativity and Web Browsing/Video PlayBack, adding to the Office Productivity suite that was used exclusively in MobileMark® 2014, by the OEMs.

The following link is the ranking of the highest battery life for platforms running MobileMark® 2018: *https://bapco.com/products/mobilemark-2018/*

IMPORTANT NOTE

AMD business-class platforms are listed as Rank #s 3, 4, 5, and 6. Notice that Rank #s 1 and 2 are fitted with much higher-than-average battery capacity. So, if normalized for equal battery capacity, AMD would take the top nine ranked positions. This is a testament to the AMD platform power efficiency, which is independent of battery capacity.

BATTERY CAPACITY

And a quick word on the actual battery capacity. Generally speaking, the bigger the better for actual battery life, but as mentioned earlier, larger capacity generally also equates to higher weight.

And although much improved with this latest generation of Li-ion batteries, they still will lose their ability to achieve and hold that maximum capacity over time. Losses here can be significant, and most OEMs expect end-users will be replacing the battery after three years of use. See the links in the Additional Resources section for more reading.

END RESULT IS BEST-IN-CLASS BATTERY LIFE EXPERIENCE

Across more workloads and real-world operating constraints, AMD strives to deliver the very best in user experience and battery life. Our Ryzen PRO 5000 series platforms continue this leadership.

Our big-picture approach focuses on an optimized platform solution, not simply AMD silicon in isolation. Having a low-power processor is required, but not sufficient. Industry-leading battery life is fragile, as stated earlier, and all components play a role in the cumulative system power. For example, if a platform's battery life is compromised with a high-power display panel, you cannot "make it up" in the rest of the system and still expect best-in-class battery life experience.

Another area where AMD pays particular attention for business-class product is the manufacturing process distribution itself. AMD culls the population to ensure commercial processors are not only the lowest average power, but also institutes strict Statistical Process Control (SPC) limits to ensure the power variability from processor to processor remains as low as possible.

It is this multilayered and system-solution approach to optimizing the performance and power balance that gives users and IT industry-leading battery life and an even better experience. It's a complicated question with a simple solution: AMD has figured out how to deliver best-in-class experience every single time.

ADDITIONAL RESOURCES

[1]https://bapco.com/products/mobilemark-2018/

[2]https://results.bapco.com/results/benchmark/MobileMark_2018

[3]https://bapco.com/news/bapco-technical-paper-battery-degradation-in-notebook-computers/#

NOTES

"Zen 2" and "Zen 3" are codenames for AMD architectures, and are not product names. GD-122

The information contained herein is for informational purposes only and is subject to change without notice. While every precaution has been taken in the preparation of this document, it may contain technical inaccuracies, omissions and typographical errors, and AMD is under no obligation to update or otherwise correct this information. In addition, AMD PRODUCTS may include errata which cause the processor to deviate from published specifications and AMD will occasionally identify such product errata without notice but is under no obligation to do so. Advanced Micro Devices, Inc. makes no representations or warranties with respect to the accuracy or completeness of the contents of this document, and assumes no liability of any kind, including the implied warranties of noninfringement, merchantability or fitness for particular purposes, with respect to the operation or use of AMD hardware, software or other products described herein. No license, including implied or arising by estoppel, to any intellectual property rights is granted by this document. Terms and limitations applicable to the purchase or use of AMD's products are as set forth in a signed agreement between the parties or in AMD's Standard Terms and Conditions of Sale. GD-140.

All battery life claims are approximate. Actual battery life will vary based on several factors, including, but not limited to: product configuration and usage, software, operating conditions, wireless functionality, power management settings, screen brightness and other factors. The maximum capacity of the battery will naturally decrease with time and use. For more information about the MobileMark 18 benchmark test, see *www.bapco.com*. GD-168.