Impact of Ad Blockers on Computer Power Consumption: A Comparative Analysis of browser ad on and built-in browsers feature

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Contents

Introduction

The Complexity of Online Advertising

Transforming the Digital Landscape: Online advertising has become a key revenue source for content creators and website owners. However, it has also introduced challenges for users, including:

- Performance
- Degradation Privacy concerns
- Increased energy consumption

Impact on User Experience: Ads often use resource-intensive elements (videos, scripts, tracking technologies), which:

- Slow down page load times
- Increase power consumption
- Negatively impact user experience

Introduction

Addressing the Challenges with Ad Blockers

The Rise of Ad Blockers: Ad blockers aim to enhance privacy, improve browsing speed, and reduce power consumption by preventing ads from loading.

- Common add-ons: AdBlock, Adblock Plus, uBlock, uBlock Origin
- Benefits: Reduce data usage, improve webpage performance
- Trade-offs: Add-ons themselves consume CPU cycles and memory

Introduction

Integrated Ad-Blocking Solutions

Some browsers like Brave and Opera have built-in ad-blocking capabilities:

- More seamless experience
- Lower system resource use compared to third-party extensions

Energy-Efficient Computing

- ARM-based processors: Focus on energy efficiency, widely used in mobile devices.
- AI accelerators (TPUs, NPUs): Optimize tasks like content filtering and ad detection more efficiently.

Literature Review

Reference	Topic	Key Findings	Methodology	Relevance to Power Consumption	Hardware/Software Focus
[1] Ren et al. (2021)	Digitalization and energy consumption in China	Demonstrates digitalization increases power demand due to internet services and data centers	Analysis of energy and internet trends in China	Highlights the general rise in energy demand due to digitalization	General hardware
[2] Ji et al. (2019)	Power demands of mobile platforms	In-app advertising on mobile devices increases energy footprint, especially in ARM systems	Empirical analysis of in-app ads on mobile devices	Discusses the impact of advertisements on energy use in mobile platforms	ARM systems
[3] Albasir (2013)	Impact of web advertisements on smartphones	Video ads cause significant battery drain and data usage on ARM-based smartphones	Case study on smartphone ad impact	Demonstrates energy consumption related to advertisements on smartphones	ARM-based smartphones
[4] Pearce (2020)	Energy conservation with ad blockers	Ad blockers mitigate power consumption by reducing computational load on ARM devices	Analysis of open-source ad blockers' impact	Shows how ad blockers can reduce energy consumption	ARM devices
[5] Souza et al. (2023)	Optimizing energy in Android devices	Ad blockers help conserve battery life and processing power	Experimental analysis using Android devices	Reinforces the role of ad blockers in reducing energy consumption	Android devices

Literature Review

[6] Suárez et al. (2024)	Comparison of ARM and RISC-V processors	ARM processors outperform RISC-V in energy efficiency under similar workloads	Comparative analysis of processor performance	Highlights the suitability of ARM for energy-efficient applications	ARM vs RISC-V
[7] Chen et al. (2017)	Eyeriss architecture for deep learning	Energy-efficient AI accelerator reduces power consumption in ARM-based systems	Development of energy-efficient AI architecture	Shows the relevance of specialized AI hardware for energy efficiency	AI accelerator (Eyeriss)
[8] Tramèr et al. (2019)	Adversarial machine learning for ad blocking	AI-driven ad blocking reduces power consumption while enhancing privacy	Application of machine learning techniques	Discusses AI's role in making ad blockers energy efficient	AI-driven systems
[9] Castell-Uroz et al. (2022)	Impact of ad blockers on performance	Content blockers reduce page load times and data usage, lowering energy consumption	Measurement of ad blockers' impact	Demonstrates reduced energy use with ad blockers	General systems

Research Objectives

- To analyze and compare the impact of various ad-blockers on power consumption across different types of websites, particularly focusing on media-heavy platforms.
- To evaluate the effectiveness of built-in ad-blockers in web browsers compared to third-party ad-blocking extensions in terms of reducing power consumption and improving overall energy efficiency.
- To assess the influence of ad-blockers on the power consumption of ARM-based CPUs, particularly in mobile and low-power systems, and identify the best practices for optimizing energy use in such environments.
- To explore how AI accelerators can be integrated with ad-blockers to reduce power consumption more effectively and assess the potential of AI hardware in enhancing the energy efficiency of web browsing.

Platforms

- Windows:

Widely used platform with robust hardware acceleration support.

- Ubuntu:

OS with varying support for hardware acceleration depending on drivers.

- Android:

Mobile OS benefiting from hardware acceleration for enhanced performance.

Tools Used

- HWiNFO:
  - Real-time system monitoring tool for Windows.
  - Tracks CPU/GPU power consumption.
- Bash Script:
  - Used a bash script to get the results on Ubuntu.
- Microsoft Excel / Data Analysis Software:
  - Used for data recording, analysis, and visualization.

Test Scenarios

- **Browser Power Consumption Tests**: Measured power consumption across various browsers (Chrome, Brave, Opera, Firefox, Vivaldi, Librewolf, Tor) to determine efficiency.
- **Ad-blocker Impact:** Tested scenarios with built-in ad-blockers (e.g., Brave, Opera) and third-party ad blockers to compare energy usage.
- **Websites Tested**: Video-heavy websites (YouTube, Dailymotion, Kisscartoon, ARYZAP, 9gag) and news websites (Dawn, Cricbuzz, ESPNcricinfo, The News, Ausaf) to observe power impacts.

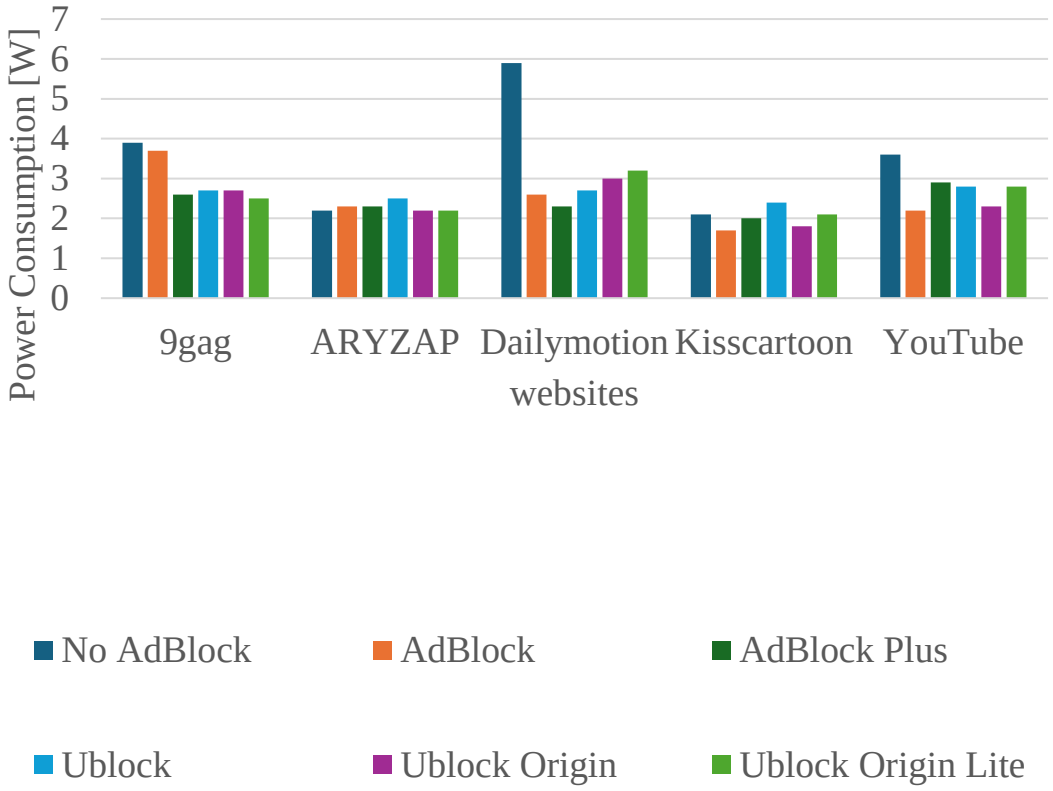
Test Scenarios

- **Hardware Platforms**: Included tests on traditional CPU/GPU setups, ARM processors, and AI accelerators to understand hardware efficiency.
- **Controlled Environment**: Standardized testing environment, including no background applications and consistent system settings for accurate measurements.
- **Playback Sessions**: Multiple sessions conducted to ensure consistency and reliability of results across tests.

Metrics for Analysis

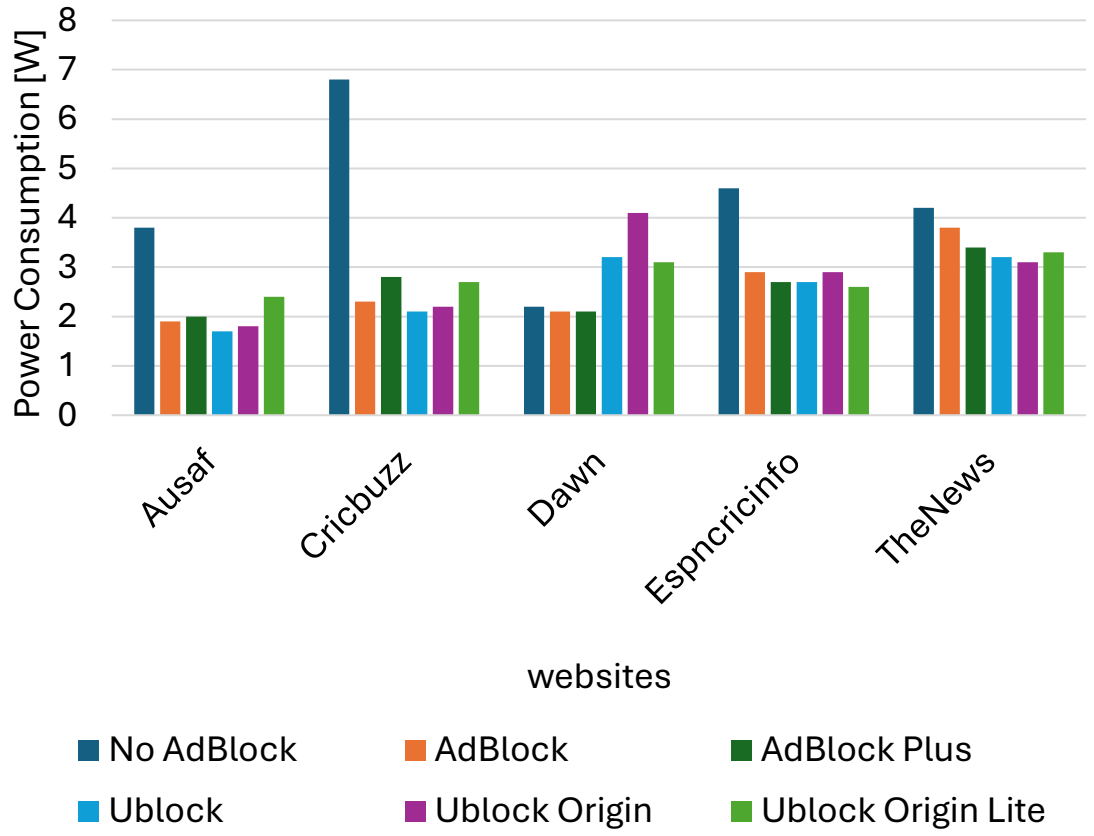
- Power Consumption:
  - CPU and GPU wattage during playback.
- CPU Utilization:
  - Percentage of CPU resources used.
- GPU Utilization:
  - GPU load during video decoding.
- Ad-blocker Performance
  - Effectiveness in reducing resource demand and energy use.

Results Comparison - Power Consumption on Multimedia Websites



- Power consumption (in watts) is compared across various websites with different ad blockers.
- Dailymotion without an ad blocker showed the highest power usage, while AdBlock Plus and uBlock Origin Lite provided significant reductions in power consumption.

Results Comparison - Power Consumption on News and Sports Websites

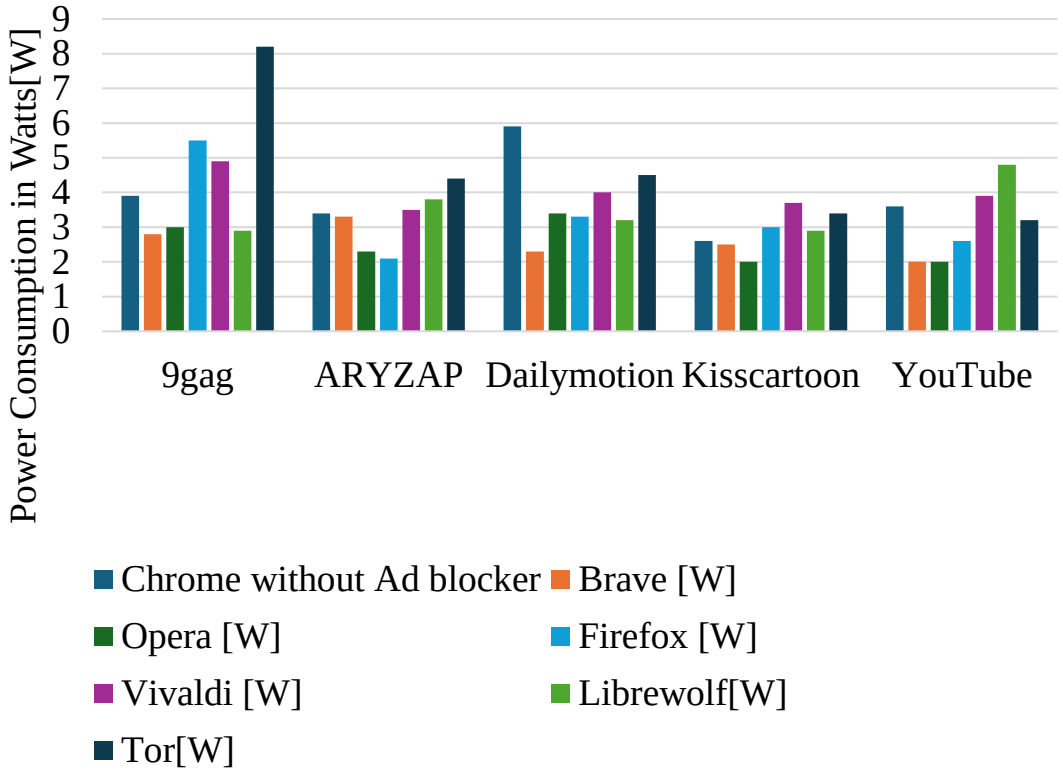


- The graph displays power consumption (in watts) across different websites with varying ad blockers.
- Browsing Cricbuzz without an ad blocker showed the highest power usage, while AdBlock Plus and uBlock Origin Lite consistently reduced power consumption across most websites.

Summary-Impact of Ad Blockers on Computer Power Consumption while Web Browsing

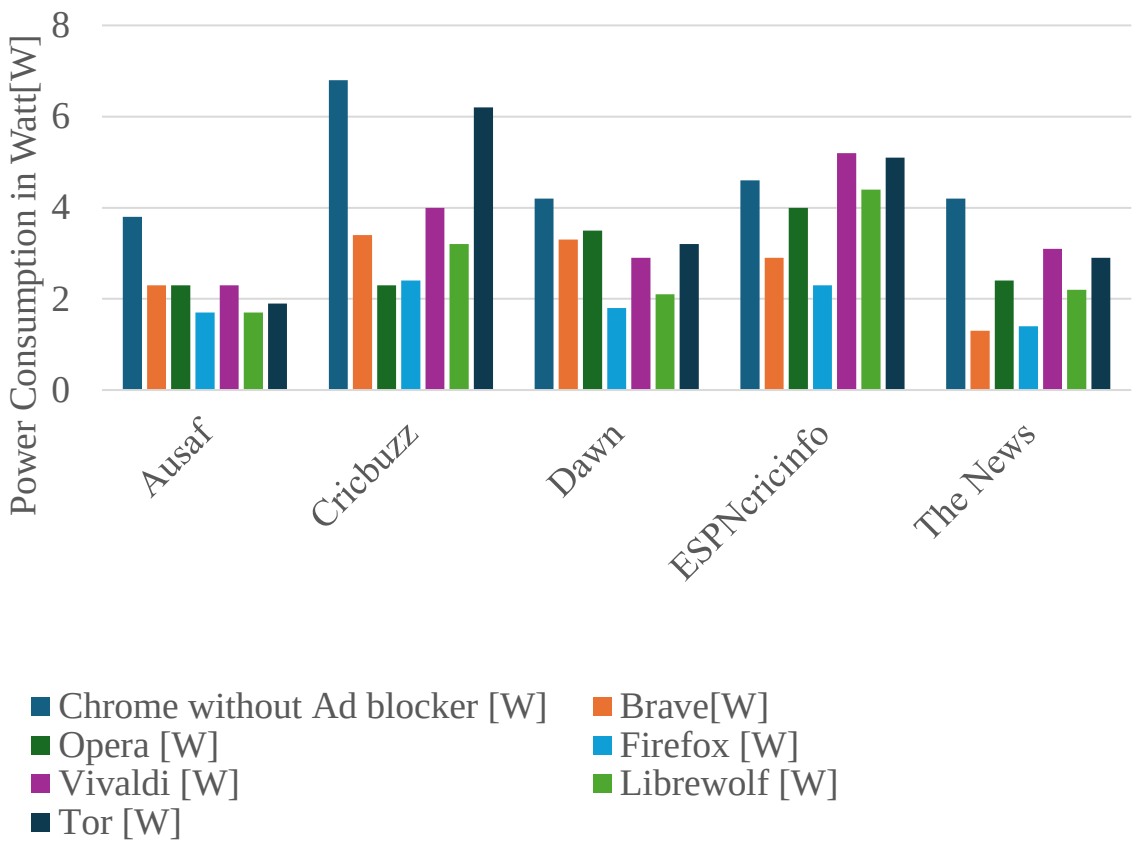
- Browsing without an ad blocker resulted in 60-70% higher power consumption compared to using ad blockers like AdBlock Plus and uBlock Origin Lite.
- AdBlock Plus and uBlock Origin Lite reduced power consumption by up to 35-40% across various websites, with Dailymotion and Cricbuzz showing the most significant reductions.

Results – CPU Power Consumption on Video Websites



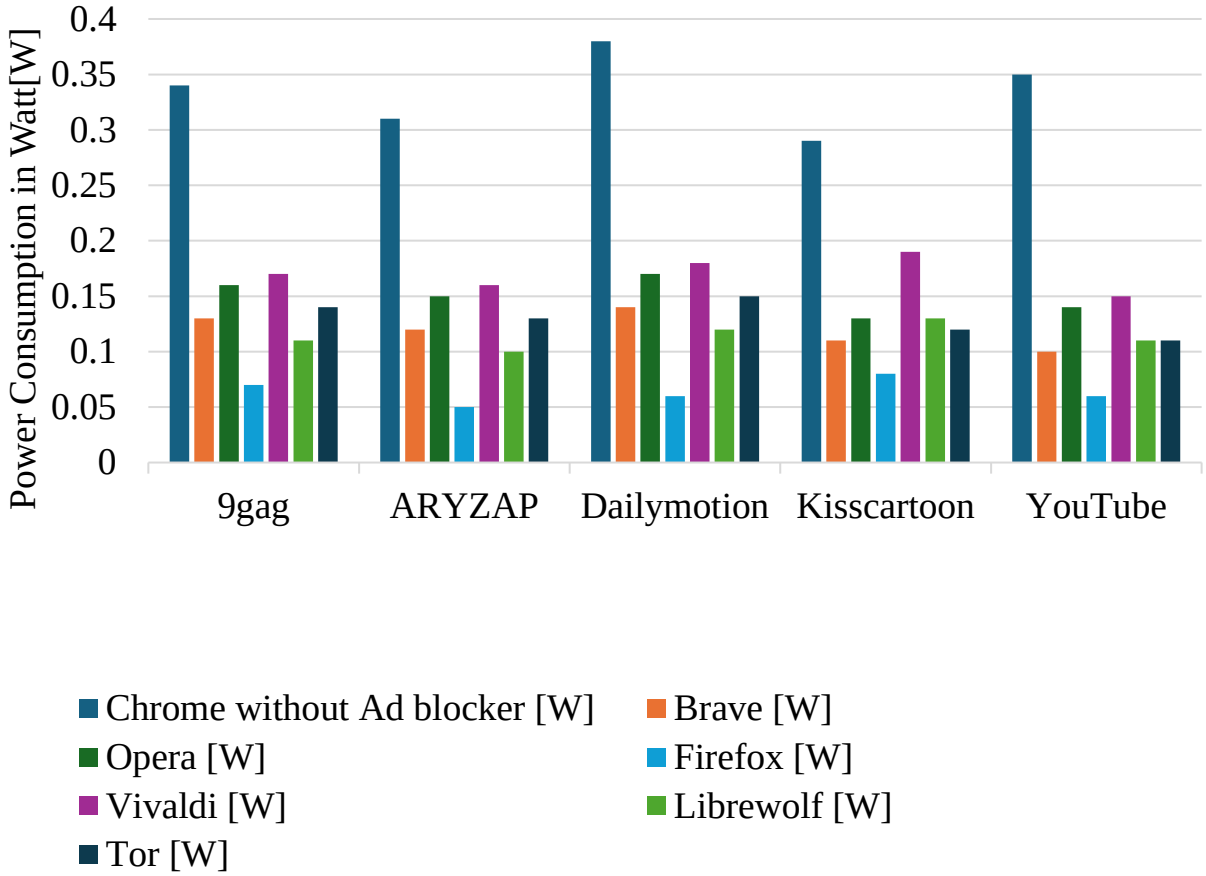
- Chrome without an ad blocker showed approximately 80% more power consumption on ARYZAP compared to other browsers.
- Brave and Opera reduced power consumption by 30-50%, with Kisscartoon and ARYZAP showing notable reductions.

Results – CPU Power Consumption on News Websites



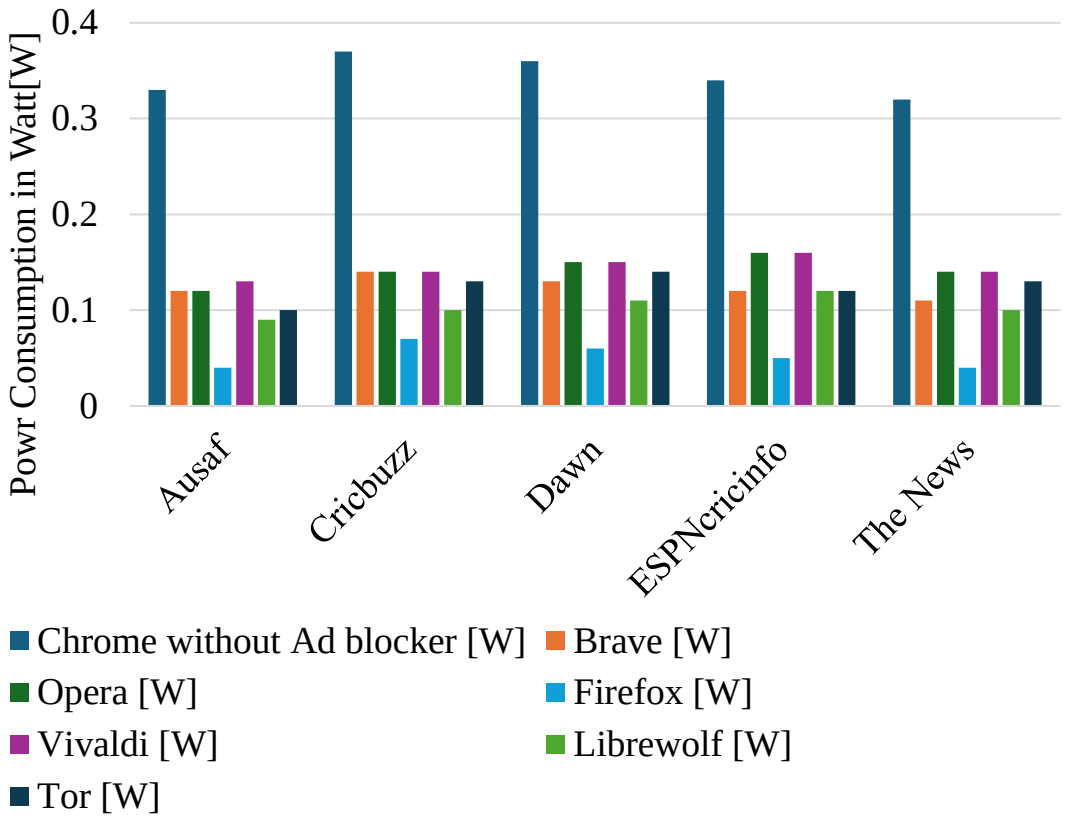
- Browsing Cricbuzz without an ad blocker using Chrome resulted in approximately 60% higher CPU power consumption compared to other browsers.
- Brave and Vivaldi showed the lowest CPU power consumption on news websites, reducing power usage by around 30-40%.

Results – GPU Power Consumption on Video Websites



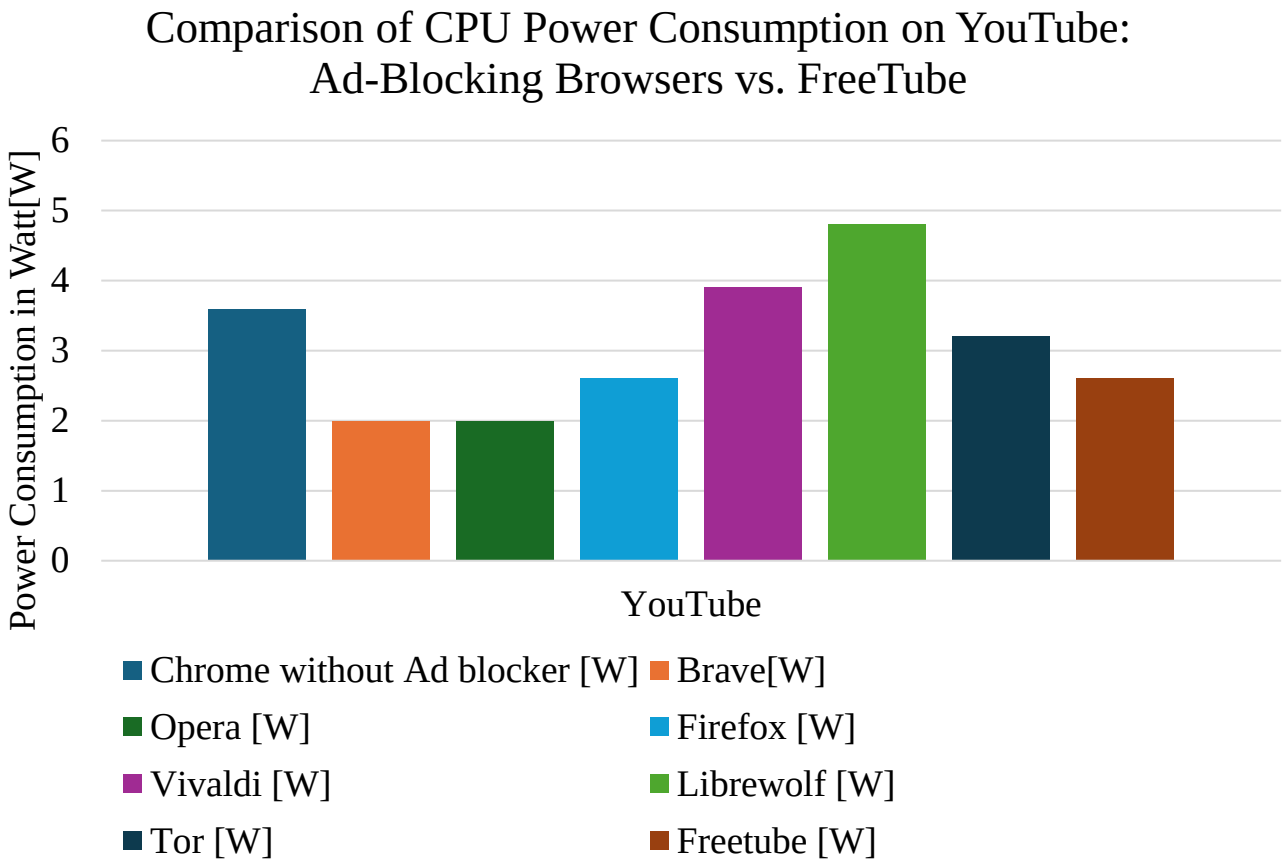
- Chrome without an ad blocker showed the highest GPU power consumption across all video websites, with up to 70% more consumption compared to other browsers.
- Brave and Firefox consistently had lower GPU power consumption, reducing usage by around 30-50% compared to Chrome.

Results – GPU Power Consumption on News Websites



- Chrome without an ad blocker showed approximately 60-70% higher GPU power consumption across news websites compared to other browsers.
- Brave and Firefox consistently reduced GPU power consumption by 30-50% compared to Chrome, with Ausaf and Cricbuzz showing significant differences.

Results – Comparison of CPU Power Consumption on YouTube: Ad-Blocking Browsers vs. FreeTube

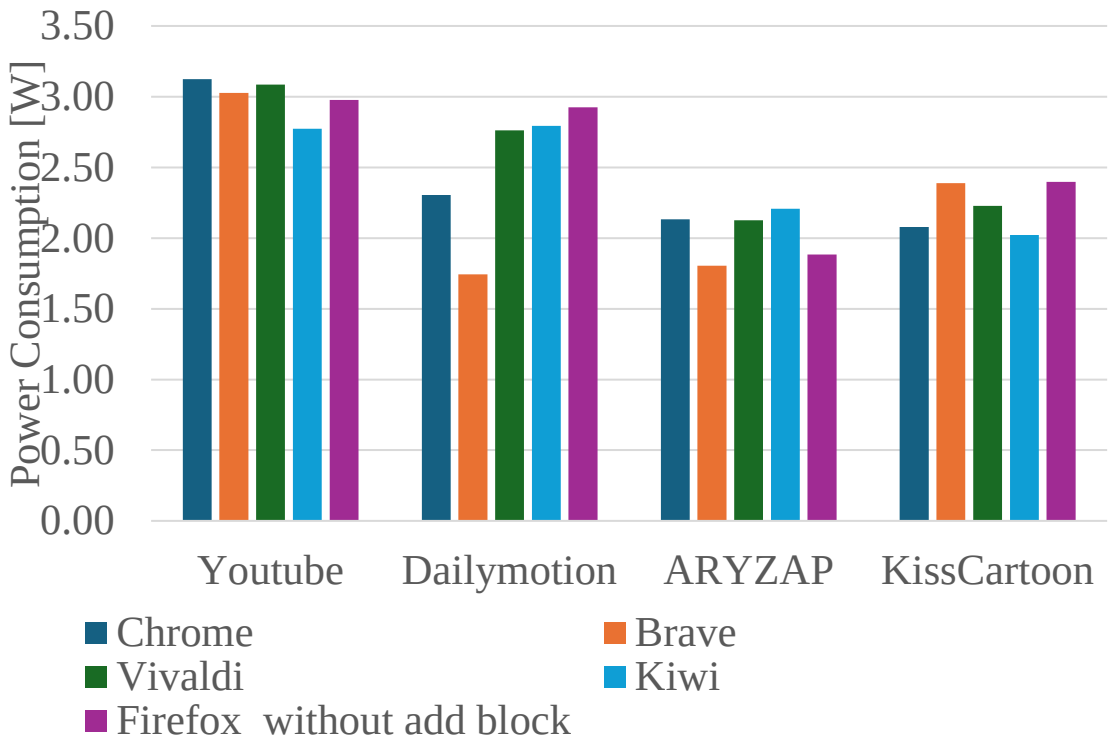


- Chrome without an ad blocker consumed approximately 40% more CPU power compared to FreeTube when browsing YouTube.
- FreeTube and Brave had the lowest power consumption, reducing CPU usage by up to 35% compared to other browsers.

Summary-The Impact of Built-in Ad-Blockers in Web Browsers on Computer Power Consumption

The data shows that Chrome without an ad blocker consistently results in the highest CPU and GPU power consumption across both news and video websites, often exceeding other browsers by 60-80%. Browsers like Brave, Vivaldi, and FreeTube demonstrated the lowest power consumption, reducing energy usage by 30-50% on average, showcasing their efficiency in minimizing resource demand while browsing.

Results Comparison - CPU Power Consumption across different Browsers



CPU Power Consumption across different Browsers

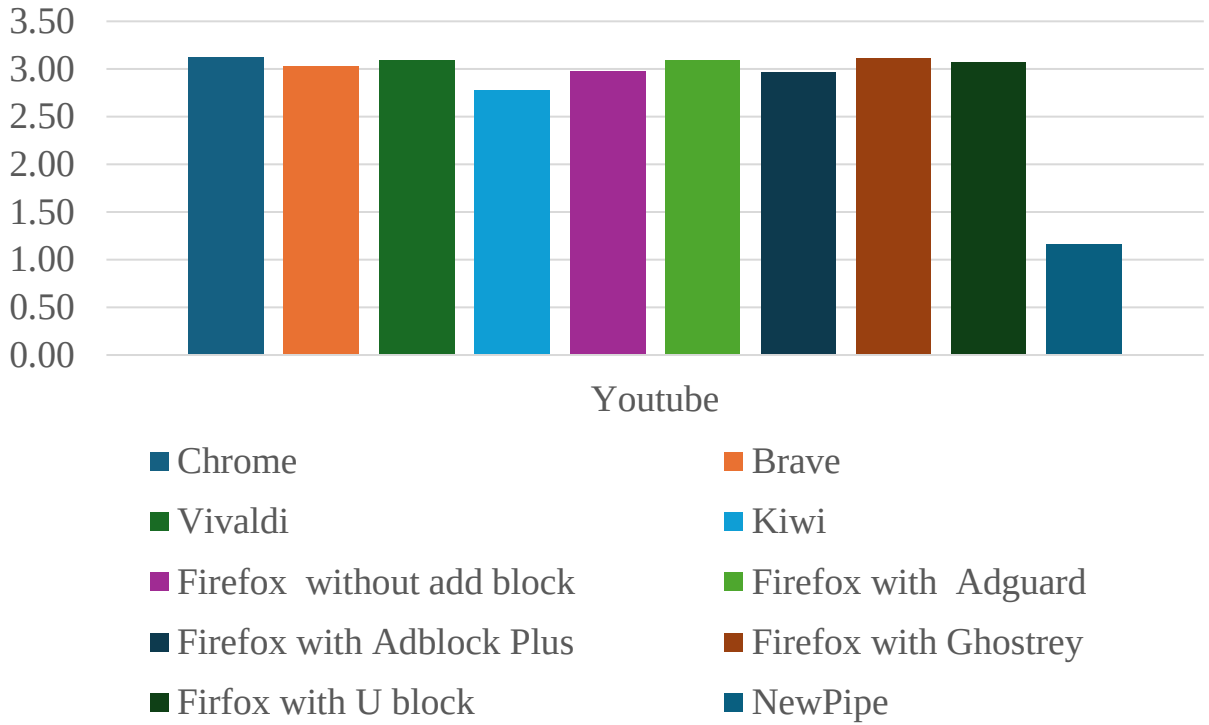
- Chrome and Firefox without an ad blocker showed approximately 20-30% higher power consumption compared to other browsers, especially on YouTube and Dailymotion.
- Brave and Vivaldi demonstrated reduced power consumption, with up to 15-25% lower power usage across all tested websites.

Results-Comparison of Firefox with Different Ad-Blockers

Websites	without ad block	Adguard	Adblock Plus	Ghostrey	U block
Youtube	3.0	3.1	3.0	3.1	3.1
Dailymotion	3.0	2.1	2.1	2.5	1.8
ARYZAP	1.9	2.0	2.0	2.0	1.9
KissCartoon	2.4	2.7	2.0	2.6	1.9

- On Dailymotion, U Block reduced power consumption by 40%, from 3.0 W (without an ad blocker) to 1.8 W, showing the most significant improvement among all tested ad blockers.
- On KissCartoon, both U Block and Adblock Plus achieved around 20-25% lower power consumption compared to not using an ad blocker, with values of 1.9 W and 2.0 W, respectively.

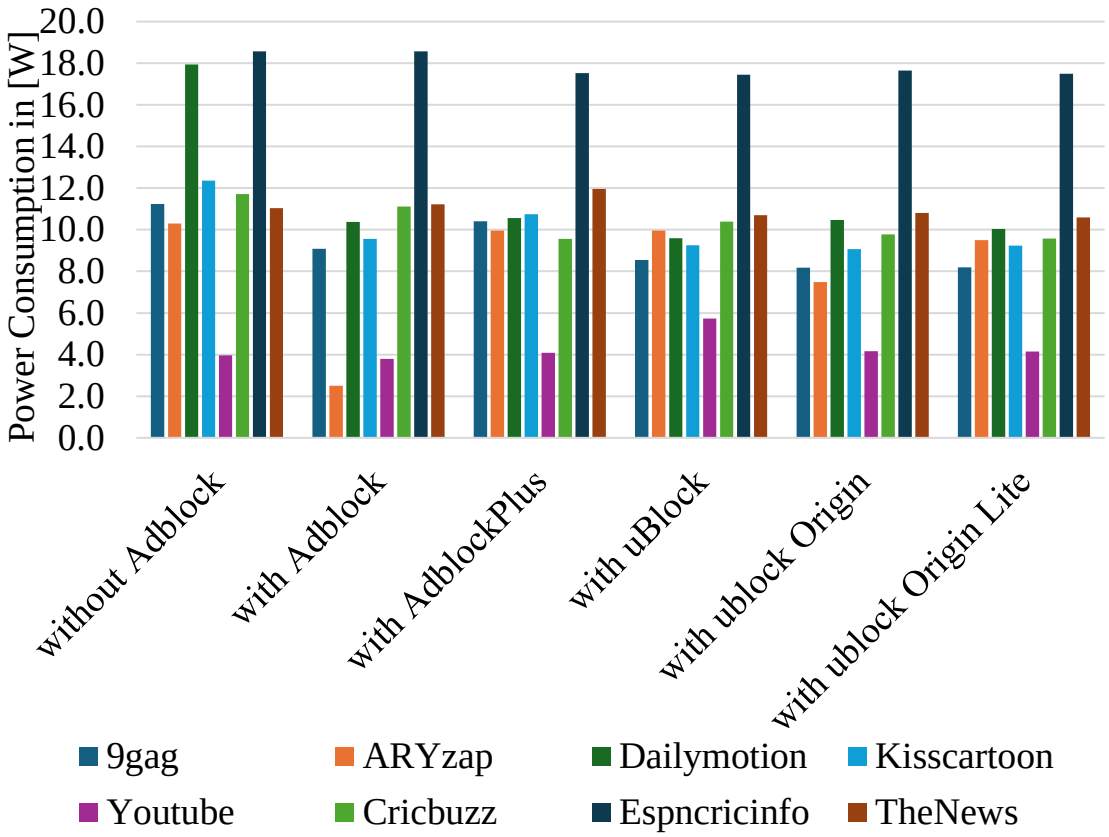
Results Comparison - CPU and Memory Utilization on raw format video



Power Consumption of different browsers with Newpipe

- NewPipe demonstrated the lowest power consumption on YouTube, reducing it by approximately 67% compared to Chrome, from 3.0 W to 1.0 W.
- Browsers like Firefox with ad blockers (Adguard, Ghostery, U Block) and others like Brave and Vivaldi maintained similar power consumption levels, around 3.0 W, indicating minimal variation among these options.

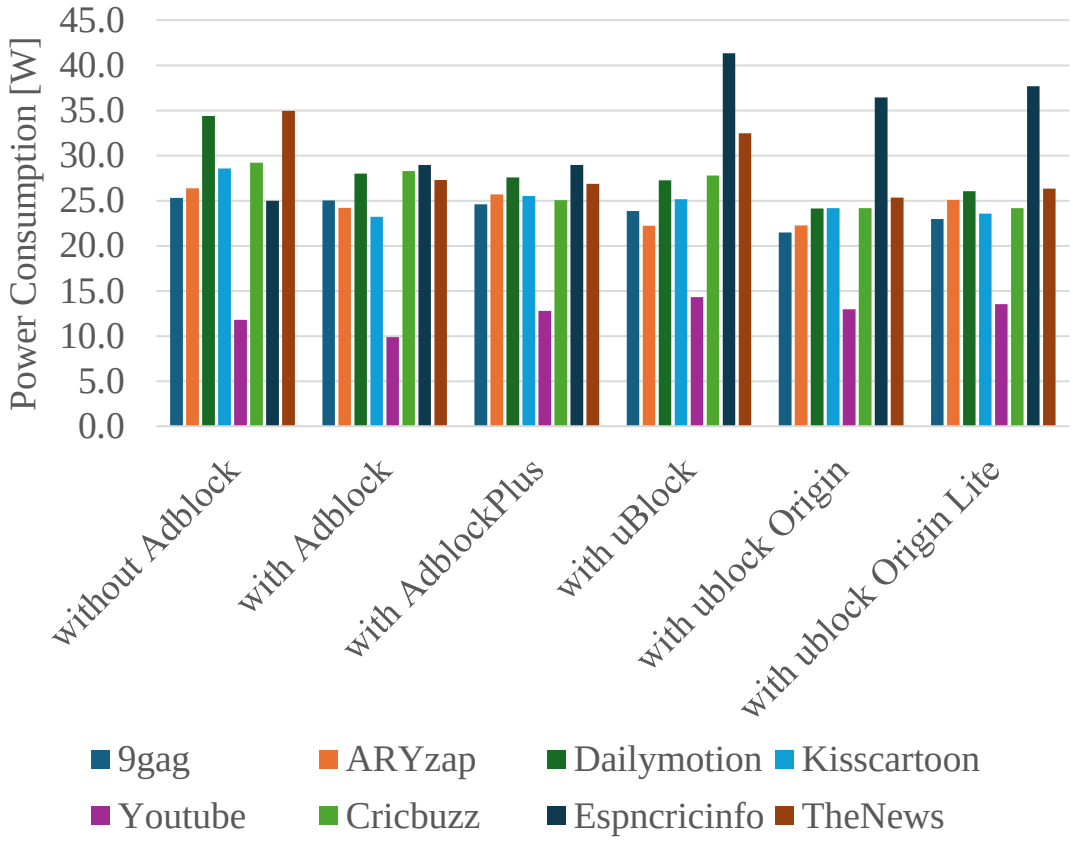
Results Comparison - CPU Power Consumption by Ad blockers on Windows



Comparison of CPU Power Consumption by Ad blockers on Windows

- Without any ad blocker, ARYZAP and Dailymotion had the highest power consumption, reaching up to 18.0 W, significantly higher compared to other websites.
- Adblock Plus and uBlock Origin Lite effectively reduced power consumption, achieving approximately 40-50% lower power usage compared to no ad blocker, particularly for websites like Cricbuzz and Kisscartoon

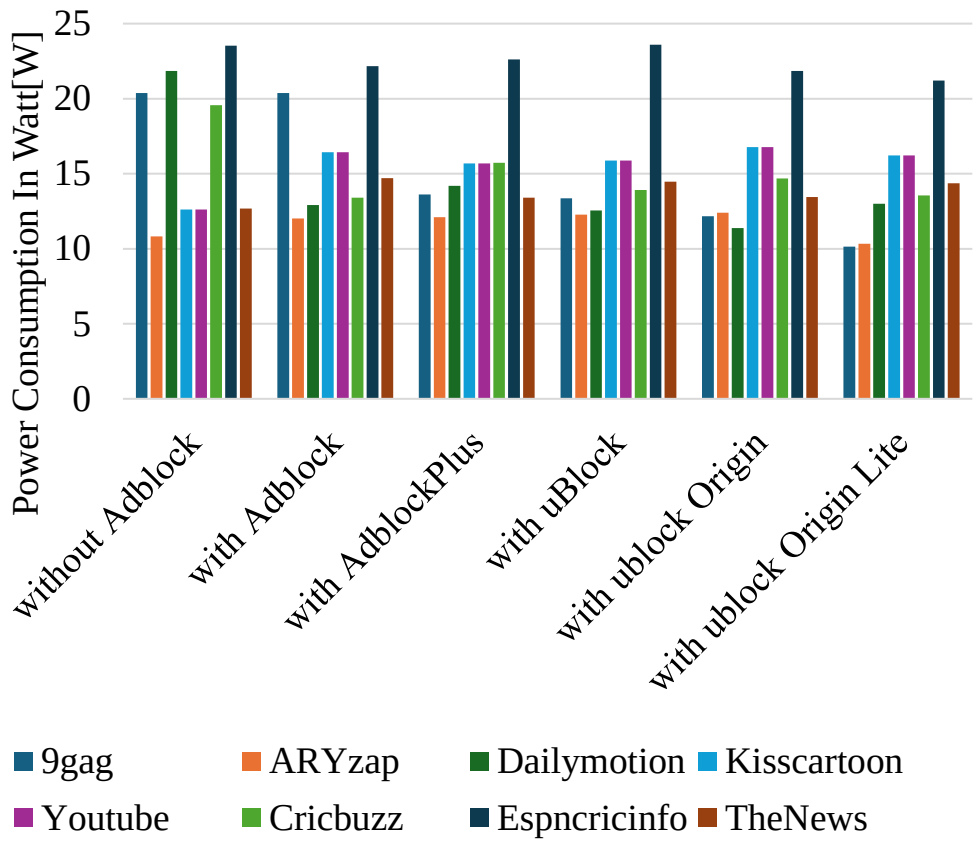
Results Comparison - GPU Power Consumption by Ad blockers on Windows



Comparison of GPU Power Consumption by Ad blockers on Windows

- Without any ad blocker, ARYZAP and Dailymotion showed the highest power consumption, reaching up to 35-40 W, significantly higher compared to other websites.
- uBlock Origin Lite and Adblock Plus reduced power consumption across most websites by approximately 20-30%, with the most notable reductions observed for Cricbuzz and The News.

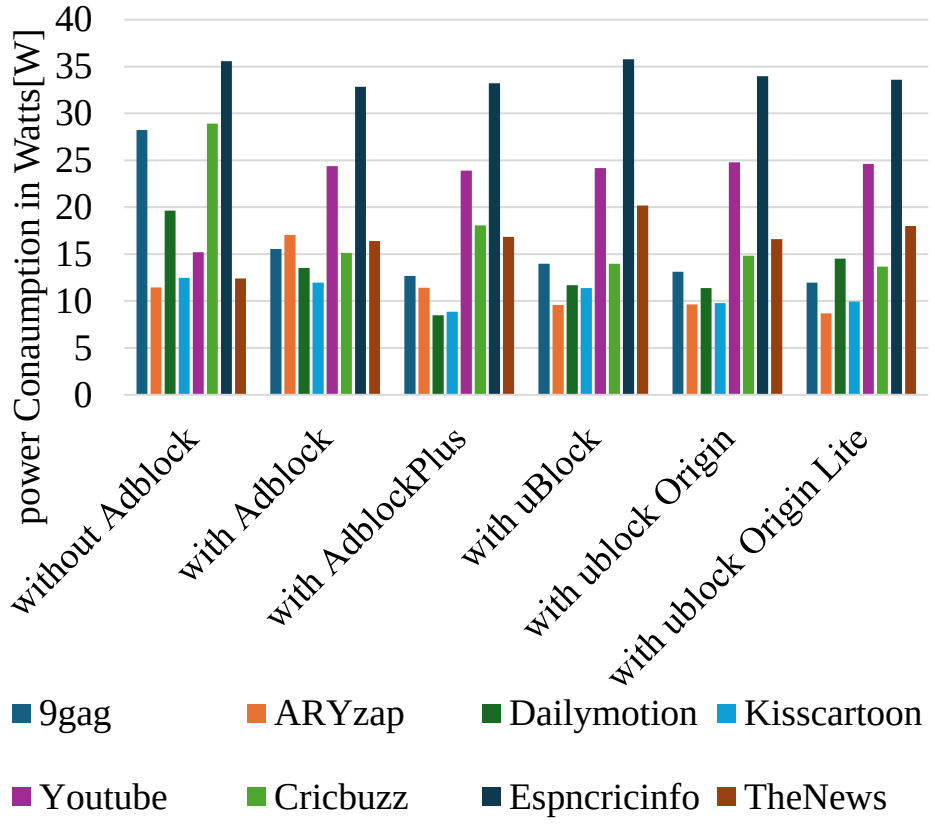
Results Comparison - CPU Power Consumption by Ad blockers on Ubuntu



Comparison of CPU Power Consumption by Ad blockers on Ubuntu

- Without an ad blocker, Dailymotion and ARYZAP exhibited the highest power consumption, reaching up to 20-22 W, while YouTube and The News showed slightly lower values.
- Adblock Plus and uBlock Origin Lite effectively reduced power consumption across all websites, achieving around 15-25% lower power usage compared to browsing without ad blockers, with notable reductions for Kisscartoon and Cricbuzz.

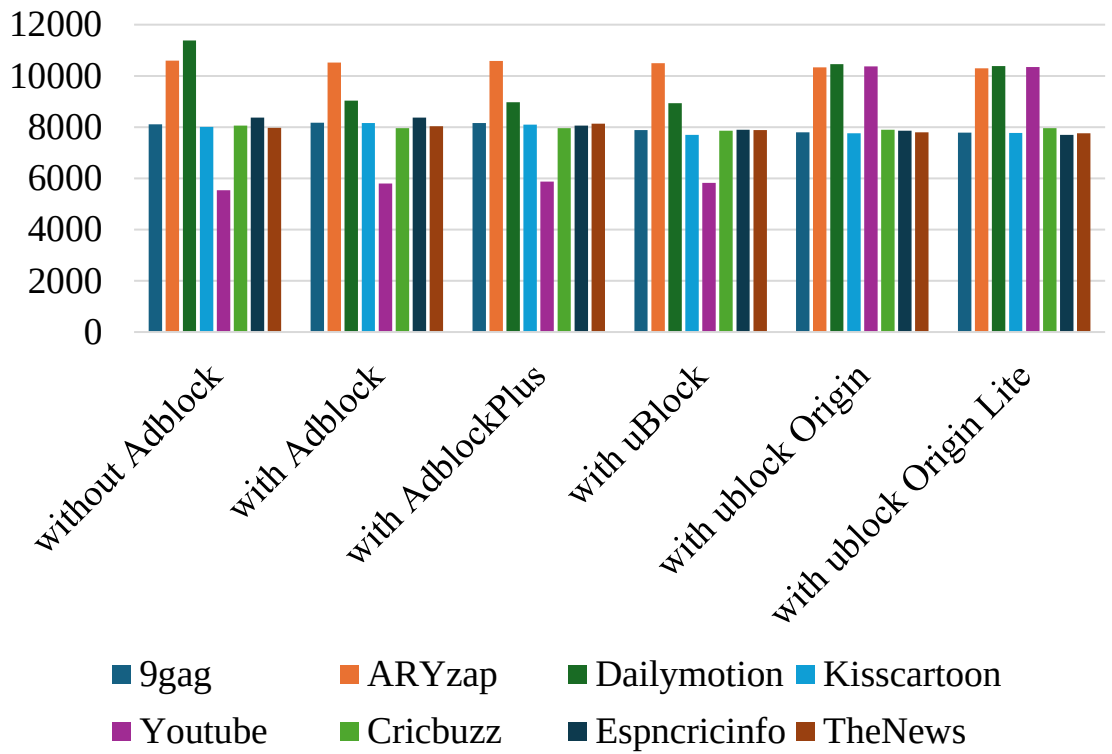
Results Comparison - GPU Power Consumption by Ad blockers on Ubuntu



Comparison of GPU Power Consumption by Ad blockers on Ubuntu

- Without an ad blocker, TheNews and Dailymotion exhibited the highest power consumption, reaching up to 35W, whereas other websites like 9gag and Kisscartoon consumed relatively lower power.
- Adblock Plus and uBlock Origin Lite effectively reduced power consumption by about 20-30% across all websites, particularly on Cricbuzz and TheNews.

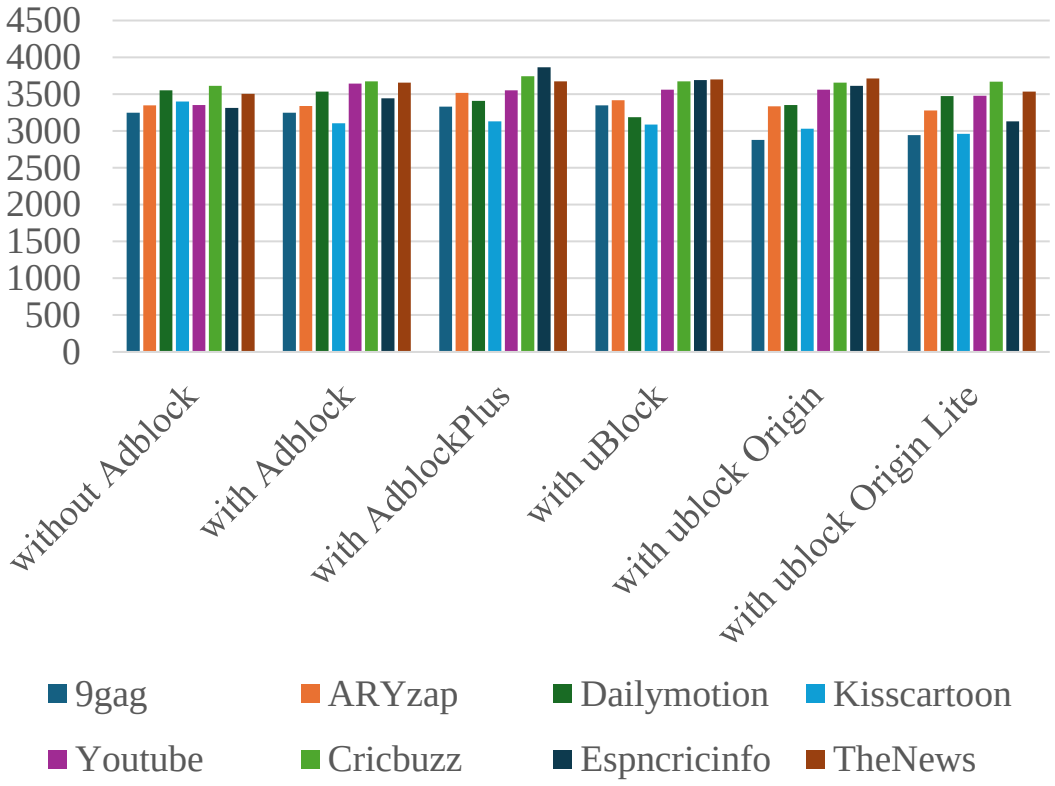
Results-Comparison of memory usage by Ad blockers on Windows [MBs]



Comparison of memory usage by Ad blockers on Windows [MBs]

- Without an ad blocker, ARYZAP had the highest power consumption, exceeding 10,000 units, while other websites like Cricbuzz and Kisscartoon showed lower values.
- Adblock Plus and uBlock Origin Lite managed to reduce power consumption by approximately 15-20% across various websites, with the most noticeable reductions seen for Dailymotion and Cricbuzz.

Results-Comparison of memory usage by Ad blockers on Ubuntu [MBs].



Comparison of memory usage by Ad blockers on Ubuntu [MBs]

- Without an ad blocker, ARYZAP and Dailymotion showed the highest power consumption, reaching up to 3500 units, whereas other websites like Kisscartoon and YouTube had slightly lower values.
- uBlock Origin Lite and Adblock Plus provided a modest reduction in power consumption, approximately 10-15%, with noticeable improvements on websites like Cricbuzz and Kisscartoon.

Impact of Ad-Blockers on Power Consumption

Comparative Analysis of Ad-Blockers:

- Ad-blockers such as uBlock Origin Lite and AdBlock Plus provide significant reductions in power consumption, especially on media-heavy websites that demand high CPU and GPU resources.
- Built-in ad-blockers in browsers like Brave and Librewolf outperform third-party extensions (e.g., Chrome) in terms of energy efficiency, lowering CPU and GPU loads more effectively.

ARM-Based CPUs and AI Accelerators

ARM-Based CPUs and Mobile Efficiency:

- Ad-blockers like uBlock Origin significantly reduce power consumption on ARM-based CPUs, extending battery life and improving system efficiency.
- This finding is crucial for mobile users looking to optimize power usage in low-power environments.

Integration of AI Accelerators:

- AI accelerators (e.g., TPUs, NPUs) enhance the efficiency of ad-blockers, enabling effective processing of ad-blocking tasks, leading to substantial reductions in power consumption.

Summary of Findings

- **Energy Efficiency with Ad-Blockers:**
  - The study shows that selecting the right ad-blocker (e.g., uBlock Origin Lite, built-in ad-blockers in Brave) can significantly reduce CPU and GPU power consumption, particularly for media-rich content.
- **Benefits for Mobile and High-Performance Systems:**
  - Ad-blockers reduce power usage on ARM-based CPUs, making them ideal for mobile devices. Additionally, integrating AI accelerators with ad-blockers can enhance energy efficiency in high-performance environments.

Conclusions

- Significant Energy Savings with Ad-Blockers: Ad-blockers like uBlock Origin and Brave's built-in ad-blocker significantly reduce power consumption, especially on multimedia-heavy websites, enhancing battery life and system performance.
- AI Accelerators for Enhanced Efficiency: Utilizing AI accelerators (e.g., TPUs, NPUs) with ad-blockers results in substantial power savings, optimizing energy use for complex web content.
- Built-in Ad-Blockers vs. Third-Party Extensions: Browsers with built-in ad-blockers (e.g., Brave, Librewolf) are more energy-efficient compared to third-party ad-blockers, reducing power consumption by up to 44%.
- Towards Sustainable Browsing: The integration of advanced hardware (e.g., ARM processors, AI accelerators) and effective ad-blocking solutions supports more sustainable, energy-efficient web browsing practices.

Research Contribution

- This research compares the effectiveness of ad-blockers like AdBlock, uBlock Origin, and others in reducing power usage, finding that uBlock Origin Lite significantly lowers CPU and GPU consumption, especially on media-heavy websites.
- Effectiveness of Built-in vs. Third-Party Ad-Blockers: Built-in ad-blockers in browsers like Brave and Librewolf are more energy-efficient than third-party extensions, reducing CPU and GPU load more effectively and offering greater energy savings and improved performance.
- Influence of Ad-Blockers on ARM-Based CPUs: Ad-blockers like uBlock Origin significantly reduce power consumption on ARM processors, extending battery life and improving efficiency, which is crucial for mobile and low-power systems.
- Integration of AI Accelerators with Ad-Blockers: AI accelerators like TPUs and NPUs enhance ad-blocker efficiency, allowing faster processing and significant reductions in power consumption, particularly on resource-heavy websites.

Future Work

- **AI Integration in Ad-Blockers:**

Explore deeper integration of AI to predict and block ads more efficiently, reducing power consumption.

- **Handling Dynamic Ads:**

Develop methods to block resource-intensive, interactive ads without increasing computational load.

- **Platform Expansion:**

Expand research to cloud services, desktops, and IoT devices for better scalability and effectiveness.

- **Data Centers and Environmental Impact:**

Investigate ad-blocker use in data centers for large-scale energy savings and quantify the long-term environmental benefits.

- **User Behavior and Education:**

Study user interactions with ad-blockers to enhance usability and promote energy-efficient browsing habits.

- **Optimizing Built-in Ad-Blockers:**

Enhance built-in ad-blockers in browsers like Brave and Librewolf for better energy-saving performance using advanced machine learning models.

List of Publications

- **KA Khan**, MT. Iqbal, M. Jamil, " Impact of Ad Blockers on Computer Power Consumption while Web Browsing: A Comparative Analysis" Accepted in *European Journal of Electrical and Computer Engineering*, September 2024.
- **KA Khan**, MT. Iqbal, M. Jamil, " The Impact of Built-in Ad-Blockers in Web Browsers on Computer Power Consumption" Accepted in *European Journal of Information Technologies and Computer Science*, October 2024.
- **KA Khan**, MT. Iqbal, M. Jamil, " Computer power consumption while using ad blocker on a system with AI accelerators" Accepted in *European Journal of Information Technologies and Computer Science, October 2024.*
- **KA Khan**, MT. Iqbal, M. Jamil, " Power Consumption While Using Ad-Blockers on ARM-Based CPU" Accepted in the 33rd Annual Newfoundland Electrical and Computer Engineering Conference (NECEC), 2024.

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Questions

- Thank you for your attention!
- Any questions or discussions are welcome.