A Comparative Analysis of Media Players Power Consumption on Windows 11 and Ubuntu 24.04.1

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Abstract— **This study investigates the energy consumption of various media players across two operating systems, Windows 11 and Ubuntu 24.04.1, focusing on the impact of hardware acceleration, codec support, and resource management on overall power usage. Media players such as VLC, MPV, Kodi, and MPC-HC on Windows, and VLC, MPV, Totem, and Parole on Ubuntu, were evaluated using tools like intel_gpu_top on Ubuntu and HWiNFO on Windows to capture detailed measurements of CPU, GPU, and memory power consumption during 4K video playback. The results demonstrate that Windows 11 media players consistently consume less power due to effective GPU utilization. In contrast, Ubuntu 24.04.1 media players exhibited higher CPU power consumption, primarily due to the lack of driver optimization for hardware acceleration.**

***Keywords*— Media players, Ubuntu , power consumption, video efficiency, energy saving.**

1. Introduction

Energy efficiency in software applications has become a key focus for developers, especially with the increasing demand for environmentally sustainable technology solutions. Media players, as one of the most commonly used software types across platforms, present a particularly important area for energy consumption analysis. With the proliferation of streaming and high-resolution media playback, the need to minimize power usage while maintaining performance is essential. This study aims to compare the power consumption of popular media players on two different operating systems—Windows 11 and Ubuntu 24.04.1—with some hardware components like the CPU, GPU, and memory.

Windows and Ubuntu, as widely-used operating systems, manage system resources differently, which can significantly affect software energy consumption. Windows 11 benefits from superior driver optimization, especially for hardware acceleration tasks, allowing for more efficient media playback. Ubuntu 24.04.1, being a Linux-based open-source system, has different resource management strategies and often lacks the same level of hardware optimization, particularly for GPU tasks. As a result, energy consumption differences between these operating systems can be notable, especially during media playback, which heavily relies on codec support, GPU utilization, and CPU resource allocation.

2. Literature Review

Energy consumption in media players has been a growing concern, especially with the increasing focus on power efficiency across platforms. Media players heavily depend on CPU, GPU, and memory, and these components' usage varies across operating systems, resulting in differences in energy consumption. Research has shown that factors such as codec support, hardware acceleration, and system resource management play crucial roles in determining how efficiently a media player uses system resources.

Chen et al. [1] conducted a study analyzing energy drain across different applications, revealing that media players on Windows 11 benefit from optimized GPU drivers. These drivers allow players like VLC and MPV to allocate resources more efficiently, particularly when handling resource-intensive tasks such as video decoding and rendering.

Park et al. [2] explored energy-efficient CPU-GPU frequency scaling, showing that platforms with better task scheduling, such as Windows 11, are more likely to achieve lower energy consumption in media playback tasks. Their findings align with the observations from this study that Windows-based media players exhibit lower CPU power consumption compared to their Ubuntu counterparts.

Akramullah [4] emphasized the role of codec support in determining energy consumption in media players. Media players supporting modern codecs like H.265 and AV1 tend to be more energy-efficient, especially on Windows, where hardware resources are better managed. MPV and VLC, with their extensive codec libraries and support for hardware acceleration, demonstrate superior performance in terms of energy efficiency.

In contrast, media players on Ubuntu, such as Totem and Parole, are often limited in their codec support and lack full hardware acceleration capabilities. Tudor and Teo [6] observed that Linux-based systems like Ubuntu generally suffer from less optimized drivers, contributing to higher CPU power consumption when playing high-definition videos. This issue is more pronounced in media players like Totem, which heavily rely on CPU processing.

Youssef [7] pointed out that media players on Windows benefit from the operating system's superior task scheduling and resource management. For example, MPC-HC on

Windows provides efficient video playback even without hardware acceleration. In contrast, Totem on Ubuntu faces limitations in both codec support and hardware utilization, leading to higher energy consumption.

The energy consumption of media players varies significantly based on the platform and optimization strategies employed. R. Hans et al. [9] compared the energy consumption of mobile devices and found that applications using software-based media players, such as those on Android, tend to consume more power than hardware-accelerated solutions. This is particularly relevant when comparing Ubuntu media players to their Windows counterparts, as the latter typically have better hardware acceleration support.

A. Power Consumption Differences in Operating Systems

The choice of operating system (OS) plays a significant role in determining how media players manage system resources, particularly in terms of CPU and GPU power consumption. Different operating systems employ varying resource allocation strategies, task scheduling, and driver optimizations, which in turn affect the energy efficiency of media players.

Tudor and Teo [6] explored power consumption across ARM-based multicore systems and found that Linux-based operating systems, such as Ubuntu, generally exhibit higher CPU power consumption compared to Windows. This is due to the differences in how these systems manage task scheduling and resource allocation. Their findings align with observations in media players, where Ubuntu players like Totem and Parole consume more CPU power compared to Windows players such as VLC.

Youssef [7] conducted an analysis of software energy consumption across different operating systems, emphasizing that Windows 11 tends to manage system resources more efficiently, resulting in lower energy usage during media playback. His findings are particularly relevant for media players like MPV and VLC, which take advantage of hardware acceleration and better driver support on Windows, reducing both CPU and GPU power consumption.

Komu et al. [8] studied power consumption in remote gaming environments, which share similarities with media player usage in terms of real-time rendering and CPU-GPU balancing. Their research found that Windows operating systems are generally more efficient in managing GPU resources, leading to reduced overall energy consumption in applications like media players.

B. Media Player Comparison (Based on Official Documentation)

Media players differ significantly in their operating system compatibility, codec support, and hardware acceleration capabilities, all of which influence their energy efficiency. The table 1 below provides an overview of the key features and limitations of the media players evaluated in this study, highlighting the factors that contribute to their overall power consumption

TABLE 1 MEDIA PLAYERS INFORMATION AND COMPARISON

Media Player	OS Support	Codec Support	Notable Limitations
VLC (3.0.11)	Windows Ubuntu	H.264, H.265, VP9, AV1	Higher CPU power consumption on Ubuntu [10]
MPV (0.33.0)	Windows, Ubuntu	H.264, H.265, VP8, VP9, AV1	Better GPU utilization on Windows than Ubuntu [11]
Kodi (19.0)	Windows, Ubuntu	H.264, HEVC, MPEG-2, VP9	Higher CPU power usage on Ubuntu [12]
MPC-HC (1.9.11)	Windows	H.264, HEVC, VP9	Not available on Ubuntu, lacks hardware acceleration [13]
SM Player (1.8.9)	Windows, Ubuntu	H.264, H.265	Less popular, limited features compared to VLC [14]
Totem (3.38)	Ubuntu	H.264, Theora, VP8	Limited codec support, higher CPU usage on Ubuntu [15]
Parole (4.14.0)	Ubuntu	H.264, Theora	Lacks advanced features, high CPU power usage [16]

3. EXPERIMENT

The purpose of this experiment is to analyze and compare the resource consumption of media players on Windows 11 and Ubuntu 24.04.1 LTS, focusing on three key metrics: GPU usage, memory usage, and CPU power consumption. To ensure consistency, a standardized video file was used across all tests. Additionally, long-term energy consumption based on CPU power was projected over a year, assuming 2 hours of usage per day.

A. Experimental Setup

Hardware Configuration

- Processor: Intel Core i7-12700H (12th Gen)
- Base Clock Speed: 2300 MHz
- Cores: 14 (6 Performance, 8 Efficient)
- Logical Processors: 20
- RAM: 16 GB DDR4
- GPU: Intel Iris Xe Graphics (Driver Version: 31.0.101.4575)

Operating Systems:

- Windows 11 Home (Build 22631)
- Ubuntu 24.04.1 LTS

Ubuntu installation specifics:

Before conducting the power consumption analysis of the media players, the Ubuntu 22.04.1 LTS operating system was installed with the recommended proprietary software option. This installation included third-party drivers and codecs, which ensured that the system could handle various media formats without additional configuration. Specifically, the proprietary software package provided support for essential multimedia codecs, including MP3, H.264, H.265, and AAC, along with drivers for graphics and Wi-Fi. This ensured smooth playback of high-definition video content across all tested media players, and also ensured that the system was equipped with the necessary drivers to fully utilize the hardware, including Intel Iris Xe Graphics, ensuring optimal performance and hardware acceleration during media playback.

Media Players Tested

- Windows 11: Kodi, MPC (Media Player Classic), MPV, SMP (Smooth Player), VLC
- Ubuntu 24.04.1: Kodi, MPV, SMP, VLC, Celluloid, Kaffeine, Parole, Totem

B. *Standardized Video File*

To ensure consistency, the same video file was used in all tests:

- Resolution: 4K (3840x2160 pixels)
- Format: MP4
- Codec: H.264
- File Size: 791 MB
- Duration: 3 minutes and 20 seconds

C. *Data Collection Tools*

Windows: HWiNFO was used to collect data for CPU power, GPU usage, and memory usage.

Ubuntu: A bash script was developed to automate data collection using intel_gpu_top for CPU and GPU usage and grep mem for memory consumption. The script for the bash file is given below.

```
#!/bin/bash
LOGFILE="Data.csv"
log_entries=()
# Write the CSV header
echo "Timestamp,CPU Package Power (W),GPU Usage
(%),GPU Power (W),Memory Used (MB)" > $LOGFILE
# Function to get memory usage
get_memory_usage() {
    mem_info=$(grep 'MemTotal\|MemAvailable'
/proc/meminfo)
    mem_total=$(echo "$mem_info" | grep 'MemTotal'
| awk '{print $2}')
    mem_available=$(echo "$mem_info" | grep
'MemAvailable' | awk '{print $2}')
    mem_used=$(( (mem_total - mem_available) /
1024 ))  # Convert to MB
    echo "$mem_used"
}
# Run the loop for 180 seconds
for i in {1..280}
do
      energy_1=$(cat /sys/class/powercap/intel-
  rapl/intel-rapl:0/ energy_uj )
      energy_2=$(cat /sys/class/powercap/intel-
  rapl/intel-rapl:0/energy_uj)
      power=$(echo "scale=6; ($energy_2 -
  $energy_1) / 1000000" | bc)
      TIMESTAMP=$(date +"%Y-%m-%d %H:%M:%S")
      echo "About to call get_gpu_info" >&2
      gpu_output=$(timeout 1s intel_gpu_top -J -s
  1000 2>/dev/null)
     echo "GPU Output: $gpu_output" >&2
      gpu_usage=$(echo "$gpu_output" | grep -m 1
  '"busy"' | awk -F ': ' '{print $2}' | tr -d ',')
      gpu_power=$(echo "$gpu_output" | grep -m 1
  '"GPU"' | awk -F ': ' '{print $2}' | tr -d ',')
      package_power=$(echo "$gpu_output" | grep -m
  1 '"Package"' | awk -F ': ' '{print $2}' | tr -d
  ',')
      echo "Parsed GPU Usage: $gpu_usage" >&2
      echo "Parsed GPU Power: $gpu_power" >&2
      echo "Parsed GPU Package: $gpu_package" >&2
      echo "Function get_gpu_info returned" >&2
      memory_used=$(get_memory_usage)
  log_entry="$TIMESTAMP,$package_power,$gpu_usage,
  $gpu_power,$memory_used"
      echo "Log Entry: $log_entry" >&2
      log_entries+=("$log_entry")
done
printf "%s\n" "${log_entries[@]}" >> $LOGFILE
echo "Logging completed. Data saved to $LOGFILE"
```

D. *Procedure*

Each media player was used to play the 4K video file for a duration of 3 minutes and 20 seconds.

Data was collected at 10-second intervals for all three metrics: GPU usage, memory usage, and CPU power consumption.

4. Results

The following results present an analysis of the GPU usage, memory usage, and CPU power consumption for each media player tested across both Windows 11 and Ubuntu 24.04.1 LTS. Long-term energy consumption based on CPU power was also calculated, assuming 2 hours of usage per day over one year.

A. *GPU Usage Across Media Players*

This subsection focuses on the comparison of GPU usage between media players on Windows and Ubuntu. The data reveals that media players on Windows tend to utilize GPU resources more efficiently than those on Ubuntu. However, individual variations exist across media players.

From Table 2, it is evident that MPC (83.60%) and MPV (77.70%) on Windows exhibit the highest GPU utilization, indicating that they offload more processing to the GPU. On Ubuntu, Totem (89.09%) and Kaffeine (69.53%) leverage the GPU most effectively. However, GPU usage remains lower across the board on Ubuntu compared to Windows.

Table 2 Comparison of Average GPU usage percentage

Player	GPU Usage (Windows)	GPU Usage (Ubuntu)
Kodi	33.54%	4.23%
MPC	83.60%	N/A
MPV	77.70%	64.44%
SMP	73.77%	14.38%
VLC	38.93%	7.65%
Celluloid	N/A	51.69%
Kaffeine	N/A	69.53%
Parole	N/A	9.89%
Totem	N/A	89.09%

B. Memory Usage Across Media Players

This section presents the memory usage for each media player on Windows and Ubuntu. Memory consumption is typically higher on Windows, suggesting that media players on this platform allocate more memory resources, possibly for caching or other background processes.

Table 3 below shows that MPC on Windows consumes the most memory, with 8797.43 MB, while Kaffeine on Ubuntu is the most efficient in terms of memory consumption at 2619.59 MB. Media players on Ubuntu consistently consume less memory compared to their counterparts on Windows.

TABLE 3 COMPARISON OF AVERAGE MEMORY USAGE

Player	MEMORY USAGE (MB) (WINDOWS)	Memory Usage (MB) (Ubuntu)
Kodi	7441.99	2928.46
MPC	8797.43	N/A
MPV	6438.90	2634.36
SMP	6438.90	3530.63
VLC	7265.10	3264.87
Celluloid	N/A	2923.91
Kaffeine	N/A	2619.59
Parole	N/A	2465.98
Totem	N/A	4456.13

C. CPU Power Consumption Across Media Players

The CPU power consumption comparison highlights a stark contrast between the efficiency of media players on Windows versus Ubuntu. Windows media players like VLC and Kodi are more energy-efficient in terms of CPU power consumption than most Ubuntu media players. Figure 1 below shows that, VLC and Kodi on Windows consume the least CPU power. Reason could be efficient hardware acceleration via DXVA and optimized proprietary drivers that offload video decoding tasks to the GPU, reducing CPU usage. Windows also has better task scheduling and resource management, further lowering power consumption.

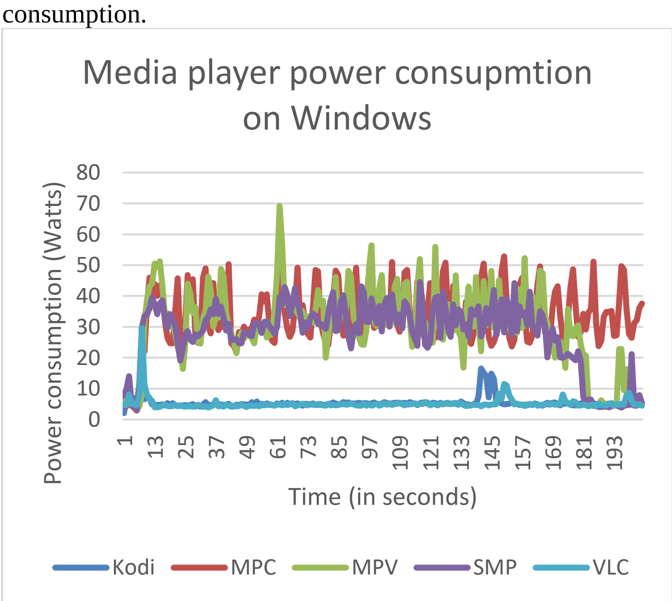

FIGURE 1 MEDIA PLAYERS POWER CONSUMPTION ON WINDOWS

Figure 2 below shows that on Ubuntu, all the media players have a similar trend of power consumption with Parole being the most power-intensive media player, consuming 31.19 watts on average, while VLC also consumes significantly more power on Ubuntu as compared to Windows.

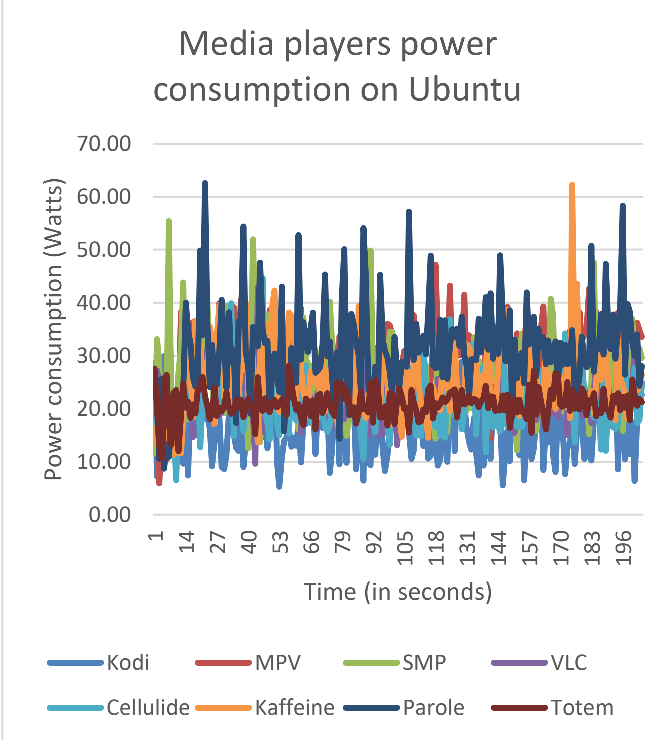

FIGURE 2 MEDIA PLAYERS POWER CONSUMPTION ON UBUNTU

D. Descriptive Statistics

GPU Usage: As demonstrated in Table 1, Windows media players generally exhibit higher GPU usage compared to their Ubuntu counterparts, with MPC and MPV leading on Windows, while Totem and Kaffeine top the list on Ubuntu.

Memory Usage: As indicated in Table 2, media players on Windows, particularly MPC, consume significantly more memory than those on Ubuntu.

CPU Power: Windows media players, especially VLC and Kodi, are much more efficient in terms of CPU power usage than Ubuntu media players (Table 3), where players like Parole and VLC consume more power.

E. Correlation Analysis

GPU Usage vs CPU Power: A weak positive correlation of 0.32 was found between GPU usage and CPU power, indicating that higher GPU usage is associated with slightly higher CPU power consumption. However, the relationship is not particularly strong, suggesting other factors may contribute to CPU power usage.

F. Informed Decision for Users

Given the widespread use of media players worldwide, these findings provide important insights for users seeking to minimize energy consumption and optimize resource usage. Choosing energy-efficient media players like VLC can result in significant energy savings over time, especially for users who frequently use media players for streaming or video playback. Considering the global scale of media player usage, the potential cumulative energy savings are substantial, both for individual users and across entire populations. These insights empower users to make informed decisions about which media players to choose based on their energy efficiency and performance characteristics.

5. CONCLUSIONS AND FUTURE WORK

This study compared the energy consumption of various media players on Windows 11 and Ubuntu 24.04.1, focusing on the impact of hardware acceleration, codec support, and operating system resource management. The results demonstrate that Windows 11 media players, such as VLC and MPV, consume significantly less power due to better driver optimization and GPU utilization. In contrast, Ubuntu media players, such as Totem and Parole, exhibited higher CPU power usage due to less optimized drivers and limited hardware acceleration. These findings emphasize the importance of selecting the right combination of media player and operating system to achieve long-term energy savings. The study highlights the crucial role that software optimization and operating system architecture play in improving energy efficiency, particularly for users who rely heavily on media playback.

Future work could expand upon these findings by investigating the energy consumption of media players on other operating systems, such as macOS or Android, to provide a broader comparison. Additionally, testing a wider range of video resolutions and formats could yield further insights into how different media players handle diverse workloads. Research into the energy efficiency of cloud-based media players or streaming services could also reveal new perspectives on energy consumption in a connected world. Exploring the influence of power-saving modes and customized user settings on media player energy consumption would offer valuable insights for both developers and users seeking to minimize their environmental impact.

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