Overview of Power Factor in Streaming

Greening of Streaming - LanguageLab - Spring 2025

Abstract

This paper examines the complexities and challenges of power measurement in streaming infrastructure, focusing on power factor and its implications for energy efficiency assessment. Through extensive industry discussions and technical analysis, we reveal how a device reported to consume 2 watts may actually require 20 watts of generation due to **power factor** effects, while infrastructure running at partial capacity may use more energy than fully loaded systems. Our goal is to help the industry move beyond simple power readings to a more nuanced understanding of energy consumption that can drive meaningful improvements in efficiency.

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1. Introduction

Current Industry Challenges

Due to its distributed nature, the streaming industry faces unique challenges in power measurement. A single streaming service involves multiple systems—from origin servers in data centres through network infrastructure spanning continents to edge caching systems and consumer premises equipment.

As demonstrated in our working group discussions by Ian Nock (IET) and Romain Jacob (ETH Zurich), a router might report using 30 watts through its management interface, but the actual power required from the grid could be 40-50% higher due to power factor effects and conversion losses.

2. Understanding Power Factor

Definition and Key Concepts

As Ian Nock explained to our working group, power factor represents the relationship between apparent power (measured in volt-amperes, VA) and real power (measured in watts, W). His measurements demonstrated this through a small set-top box example: in standby mode, with a power factor of 0.1, a device showing 0.5 watts of consumption actually requires 5 watts to be generated.

We found this article to be a very useful 'primer':
https://www.packetpower.com/blog/power-factor-explained

Critical Variations

Through working group measurements, we documented notable variations in power factor across different operating modes (all numbers below in watts):

- TVs: 0.9 when displaying content to 0.1 in standby
- Set-top boxes: 0.4-0.7 in active use, dropping to 0.1-0.2 in standby
- Network equipment: 0.5-0.8 load dependent

We have collectively seen a wide range of data points relating to Data centres, but testing was beyond the scope of this LanguageLab exercise. However, the article mentioned above notes that data centres are typically maintained well above 0.9 via active management.

Consumer vs. Commercial Impact

Poor power factor has direct financial implications for commercial environments, particularly data centres, creating strong incentives for active management.

In contrast, consumer environments lack these incentives, leading to widespread use of low-quality power supplies with poor power factor characteristics. The cumulative effect of millions of consumer devices with poor power factors represents significant opportunities for the industry to optimise and improve.

3. Measurement Challenges

Base Load Dominance

Romain Jacob's research revealed that many network routers typically consume 80% of their peak power consumption even during minimal activity. This high base load challenges the common misconception that power consumption scales linearly with data transfer. Even with aggressive power-saving features, consumption could only be reduced by 20-25% during low-traffic periods.

Power Factor Variation

Router measurements demonstrated how power factor varies significantly with load - excellent (0.95+) at full capacity but dropping substantially (0.6 or below) under light loads. This variation means equipment might require nearly **twice the power generation during low-traffic periods**.

System-wide Effects

As Stan Moote (IABM) emphasised, the lack of standardised measurement approaches presents persistent challenges. Equipment from different manufacturers provides varying levels of power measurement capability, making direct comparisons difficult and complicating system-wide efficiency assessment.

4. Practical Implications

Impact on Efficiency Metrics

Traditional metrics often fail to capture power factor effects. For example, a device drawing 2 watts with a power factor of 0.1 actually requires 20 watts of generation, challenging many current efficiency assessments. As Ben Schwarz noted, metrics like watts per stream can be misleading when power factor effects aren't considered.

Regulatory Considerations

Current regulations often take an oversimplified approach. While well-intentioned, the EU's 0.5W maximum standby power requirement doesn't account for power factor effects. Due to poor power factor in standby mode, devices meeting this requirement might still require five to ten times more power generation.

5. The Path Forward

Key Recommendations

1. Develop standardised measurement approaches that account for power factor effects
2. Implement repeatable measurement methodologies
3. Consider power factor characteristics in equipment selection
4. Focus on system-wide efficiency rather than component-level metrics

Future Research Needs

- Better understanding of power factor effects in edge computing environments
- Impact of growing consumer device deployment
- Relationship between power factor and emerging streaming technologies
- Grid-level effects of streaming infrastructure

Glossary of Terms

Power Factor: Ratio between real and apparent power. Perfect efficiency (1.0) means all supplied power is used for intended purposes.

Real Power: Actual power consumed, measured in watts (W).

Apparent Power: Total power supplied, measured in volt-amperes (VA).

Reactive Power: Power that must be generated but not used is arguably ‘wasted’ energy.

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