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Fraunhofer FOKUS Institute for Open Communication Systems

Green Streaming – The role of Consumers and Devices

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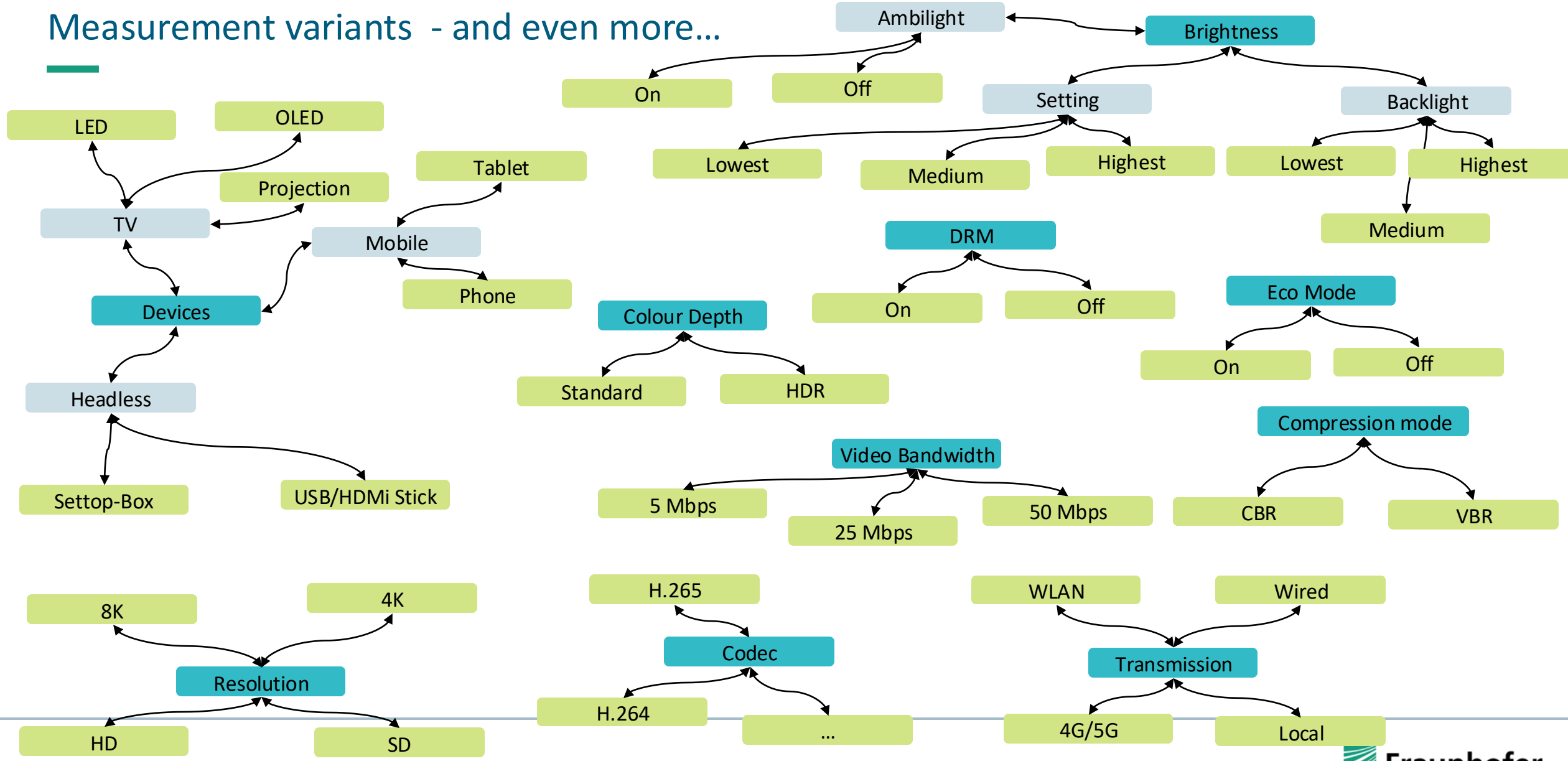
Measurement variants - and even more…



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Our approach

End-Device Measurement

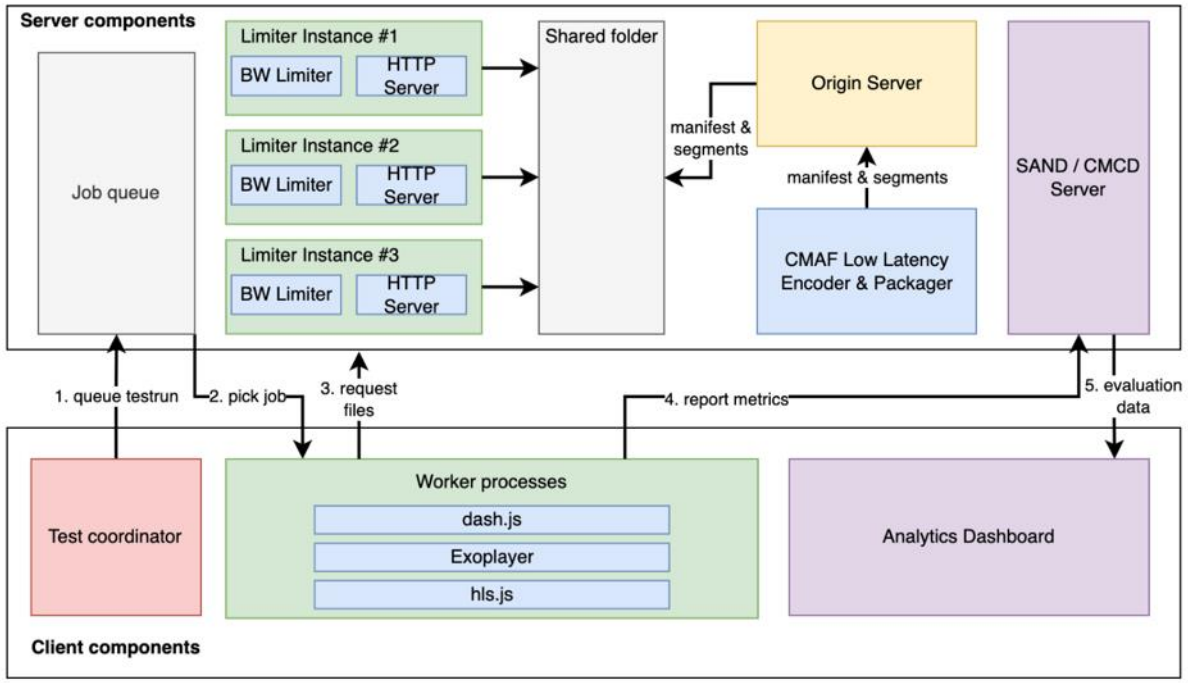
- ***How*** we want to measure?
  - controlled, synchronized, automated
  - combining energy measurements (real-time power meter data) with streaming session data and all relevant attributes

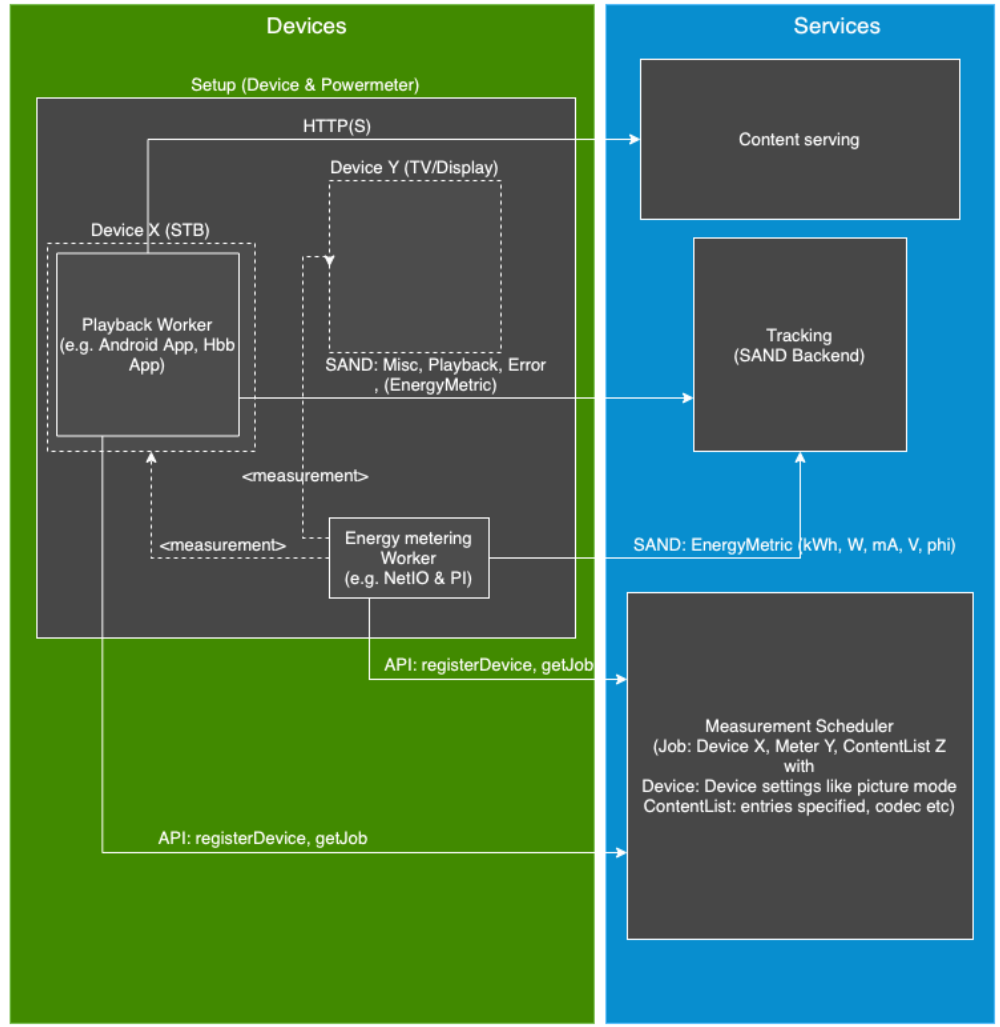
- ***What*** we want to measure?
  - *Attribute Triplet* comprising of
    - **Content Attributes** (complexity, luma, color histograms, codec, frame-rate, gop size, encryption, container, packaging, …)
    - **Device Attributes** (display technology, brightness level, stationary/mobile, light conditions, player type, ABR algorithm, …)
    - **Network Attributes** (connectivity type, bandwidth, jitter, packet loss, …)

  - The values of these attributes are known/set prior to measurement, all are tracked, some are iterated/varied (value ranges)

Automate Measurements utilizing and enhancing the FOKUS ABR Testbed

Architecture overview





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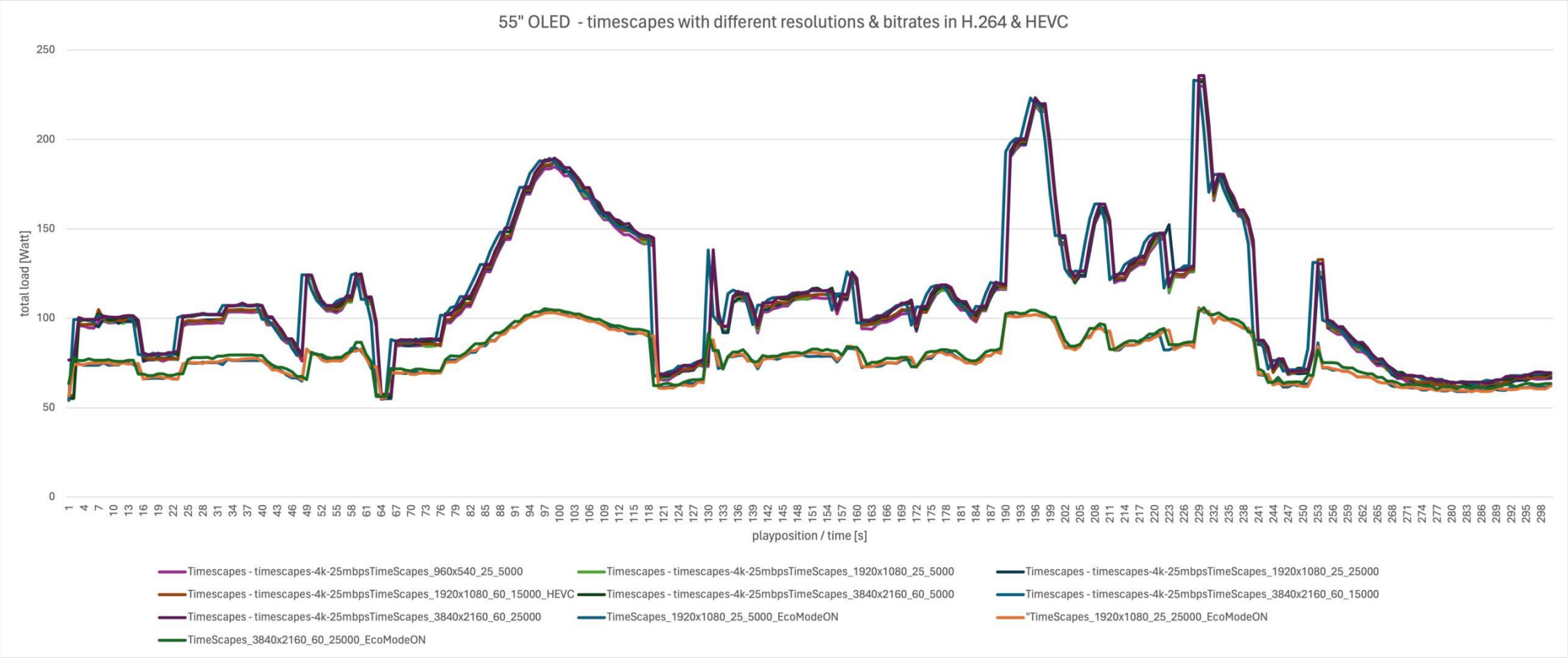
Comparing different stream settings including bitrate, resolution



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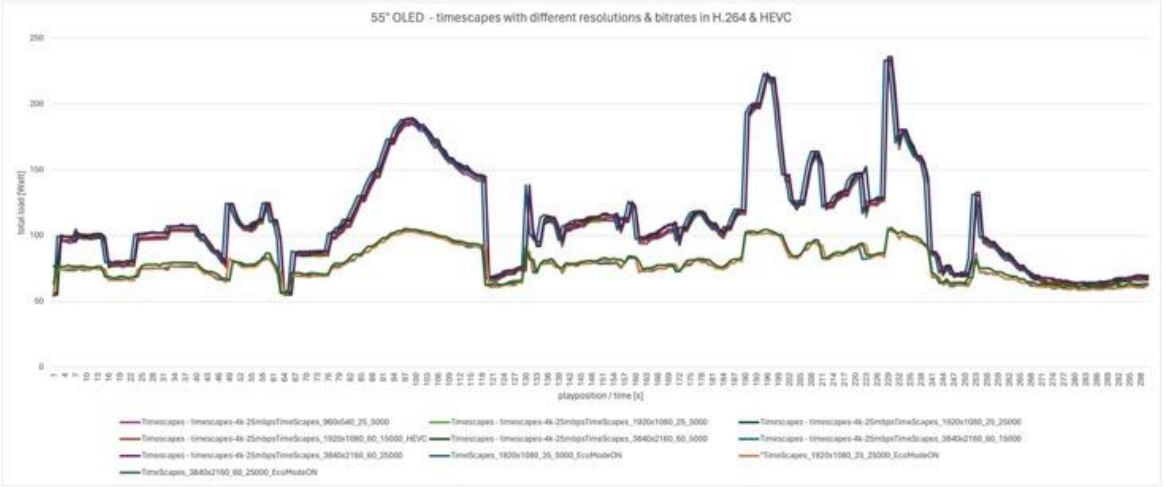
Comparing different stream settings including bitrate, resolution

- differences in power consumption between the various renditions in SD, HD, and UHD with bitrates ranging from 5Mbps to 25Mbps are marginal
- compared to the brightness of the content they have almost no impact on the device's energy consumption to playback streaming content
- activating the energy-saving mode results in energy savings of ~50% in individual scenes, surpassing the values from our artificial content.



Key findings:

- Luminance affects energy consumption on TVs - not a surprise 💡💡
- Bitrate does not have a major effect on the energy consumption when streaming on a Smart TV
- TV Eco Modes are efficient and save energy (much more than trying to stream with a lower bitrate)
- OLED is different than QLED is different than LCD (edge LED & full LED)

OLED 55" TV, playing the 5-minute test content	
960×540@25fps@5000kbps	3840×2160@60fps@25000kbps
0,75365 Wh	0,78052
thats a difference of 0.026863489 Wh	
If we extrapolate the energy consumption of these 5 minutes to a daily usage of 5 hours of streaming for 365 days, the total energy difference amounts to 588.31 Wh, or 0.58831 kWh → this is ~0.20€ / year	

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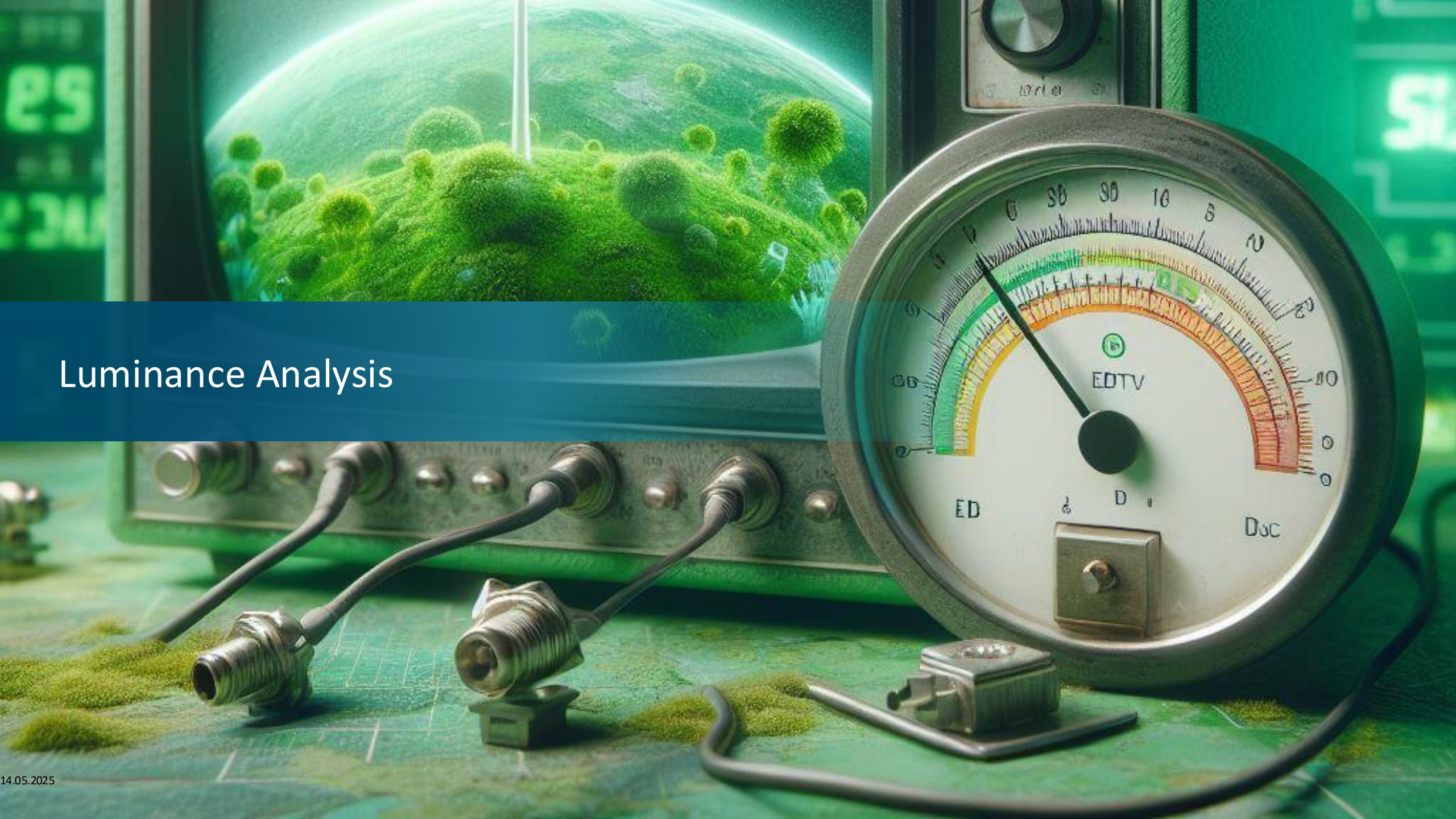
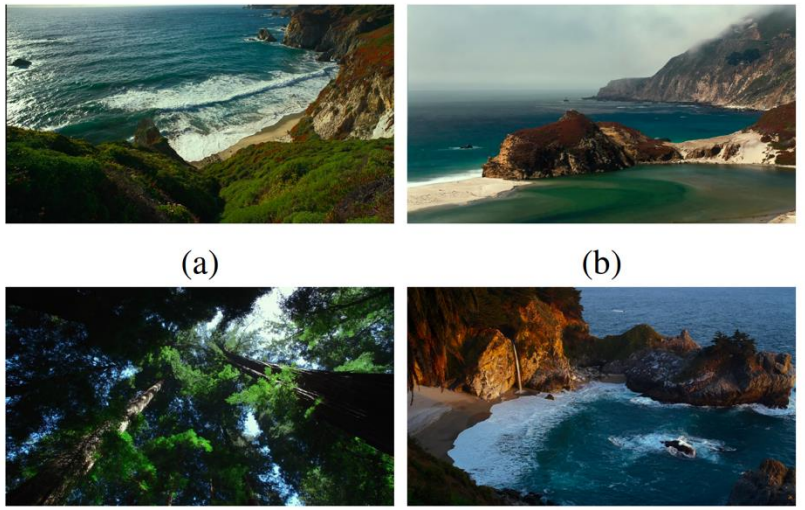
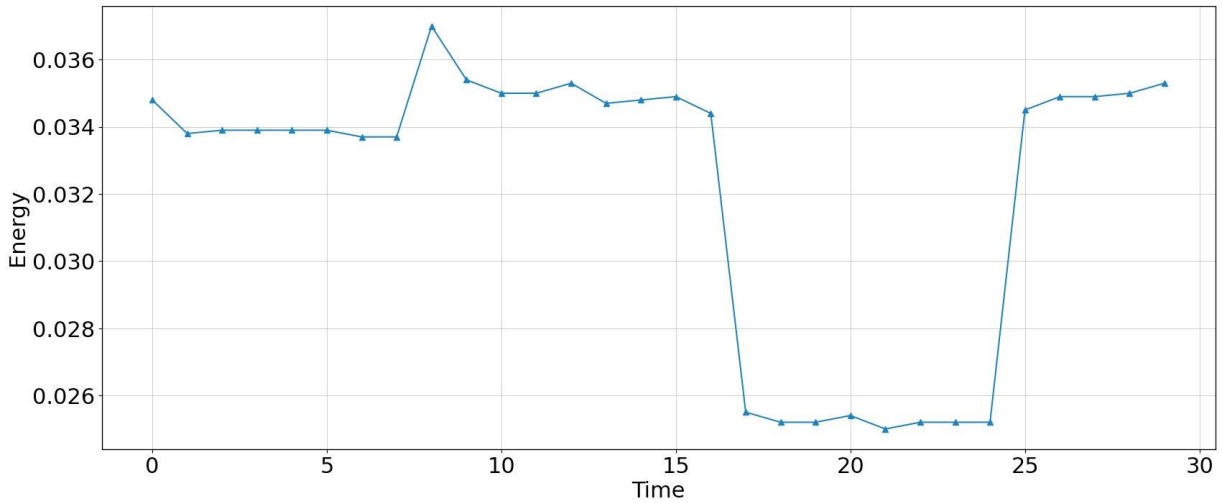
Luminance Analysis

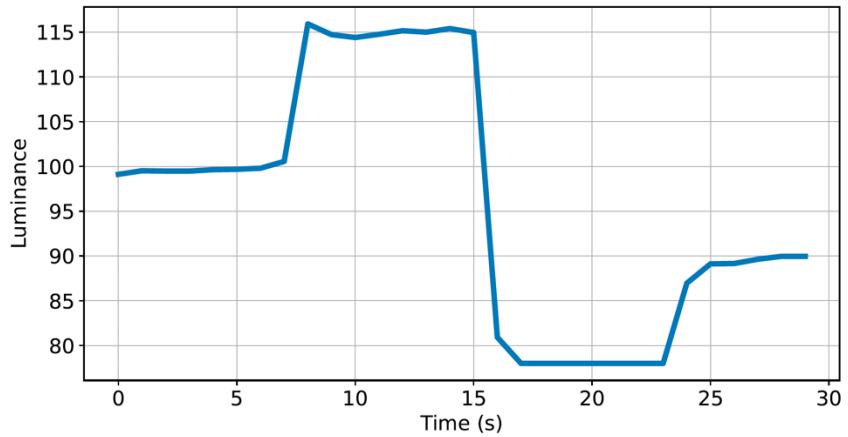


Energy and Video Luminance Correlation

- Question: Can we reduce the video luminance to save energy while maintaining the perceptual quality?







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Results

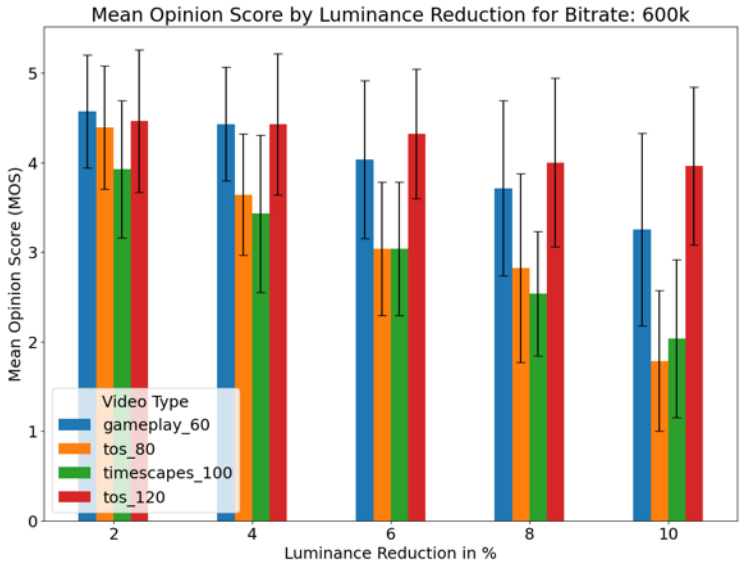
Subjective Score

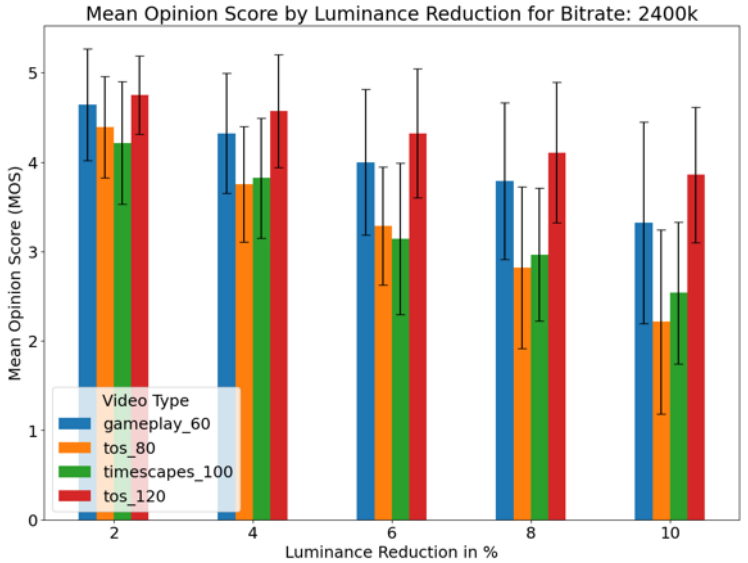
- $5 = Excellent$
- $4 = Good$
- $3 = Fair$
- $2 = Poor$
- $1 = Bad$

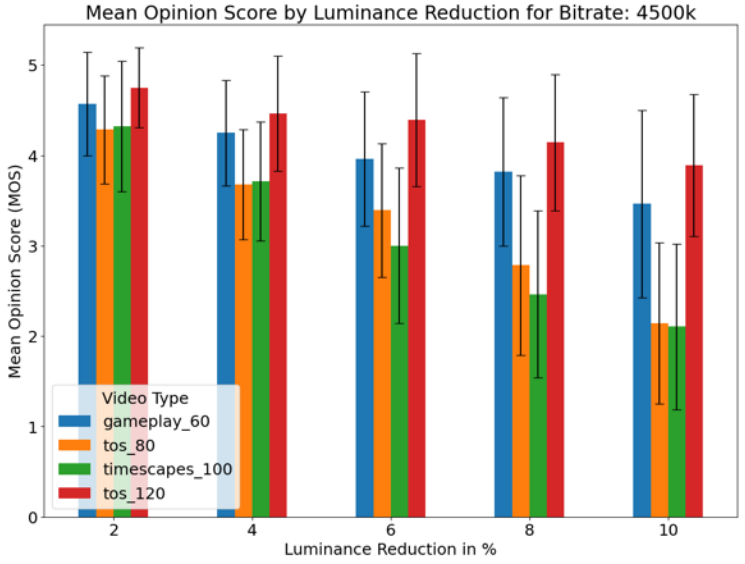
- Darker videos consume less energy
- Bitrate/Resolution has a measurable, but marginal affect on energy consumption of TVs
- MOS is decreased with the increase of video's luminance reduction

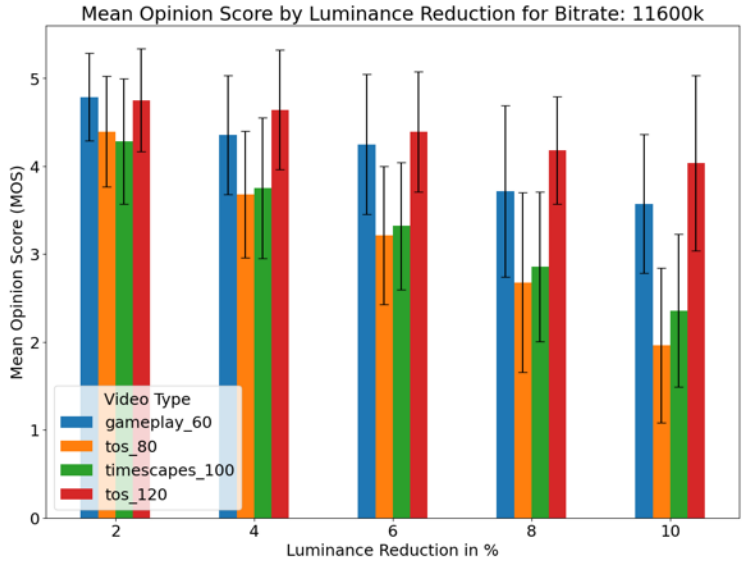
Video brightness can affect the energy consumption of consumer devices

Videos	Max. luminance reduction*	Energy Saving**
Gameplay_60	6%	4%
ToS_120	10%	14%
Others	2%	3.7%









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FAMIUM GreenView

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FAMIUM GreenView

Overview

- FAMIUM GreenView is a green streaming solution designed for SmartTVs and HbbTV
- Enables energy-efficient streaming without altering original content, enhancing sustainability in media consumption.

Core Components

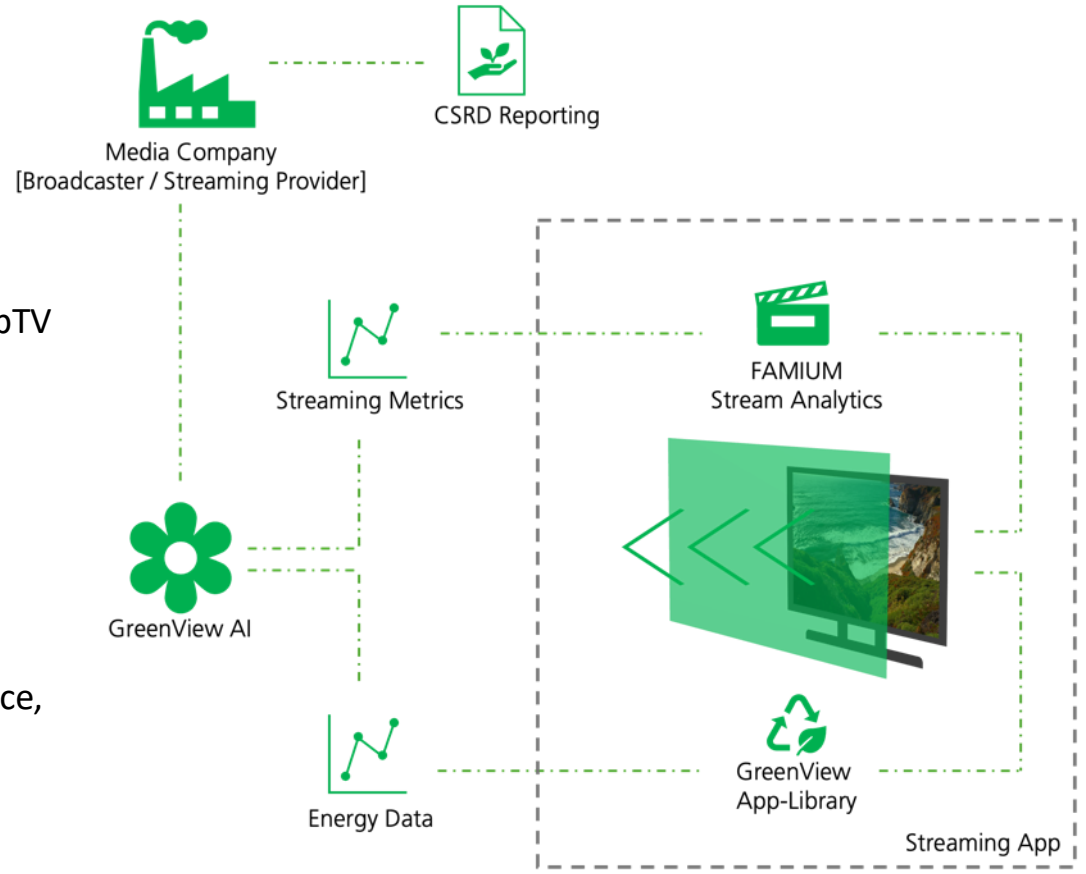
- Integration of a client-side library into streaming service applications.
- Backend component provides customized settings for each streaming session.
- Utilizes AI model to adjust streaming parameters based on context (content, device, display type) for optimal energy efficiency.

GreenView AI

- AI model trained using datasets from FAMIUM Green Streaming Measurement Framework and FAMIUM Stream Analytics.
- Enables precise adjustments on streaming device / Smart-TV for energy-efficient playback.

Compatibility and Accessibility

- Currently available for Android-based Smart-TVs via ExoPlayer and HbbTV.
- Extends benefits to OTT, media library content, and traditional linear broadcast TV.



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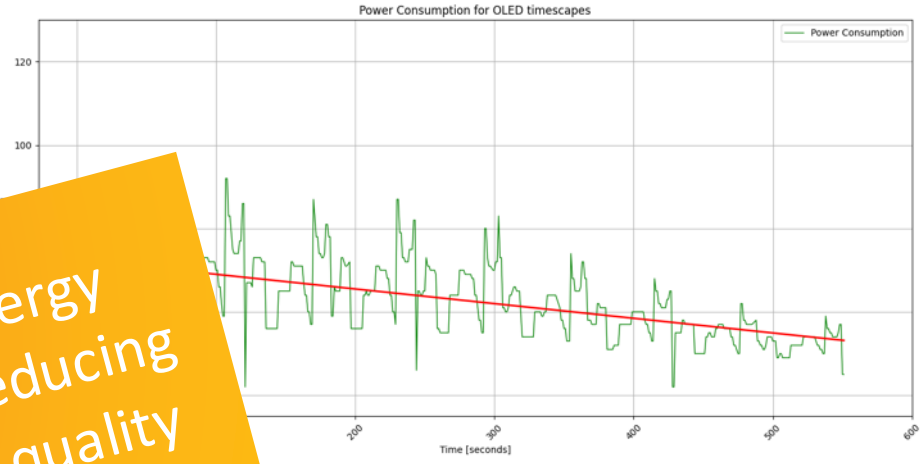
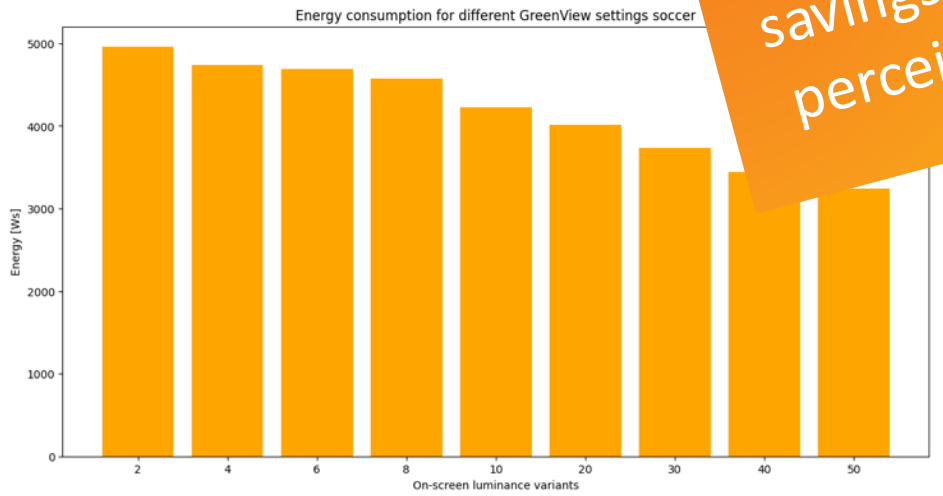
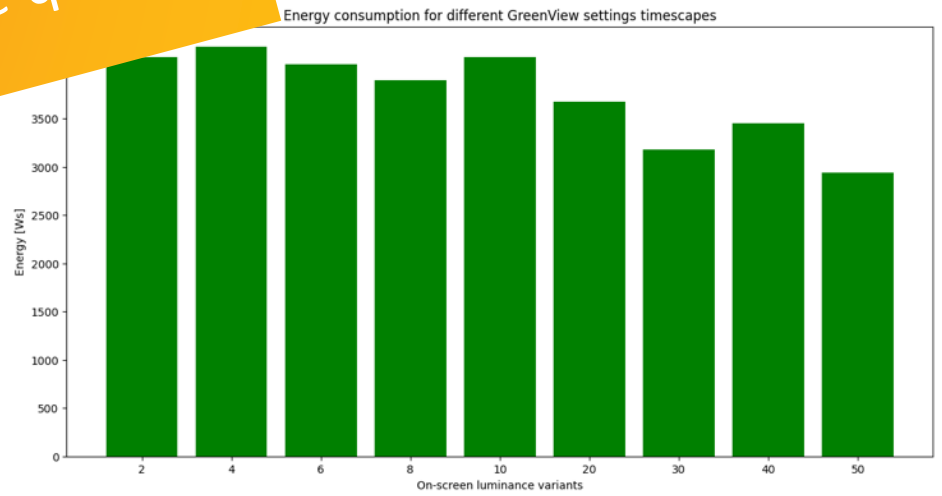
GreenView enabled Energy Savings



up to 15-20% energy savings without reducing perceived image quality





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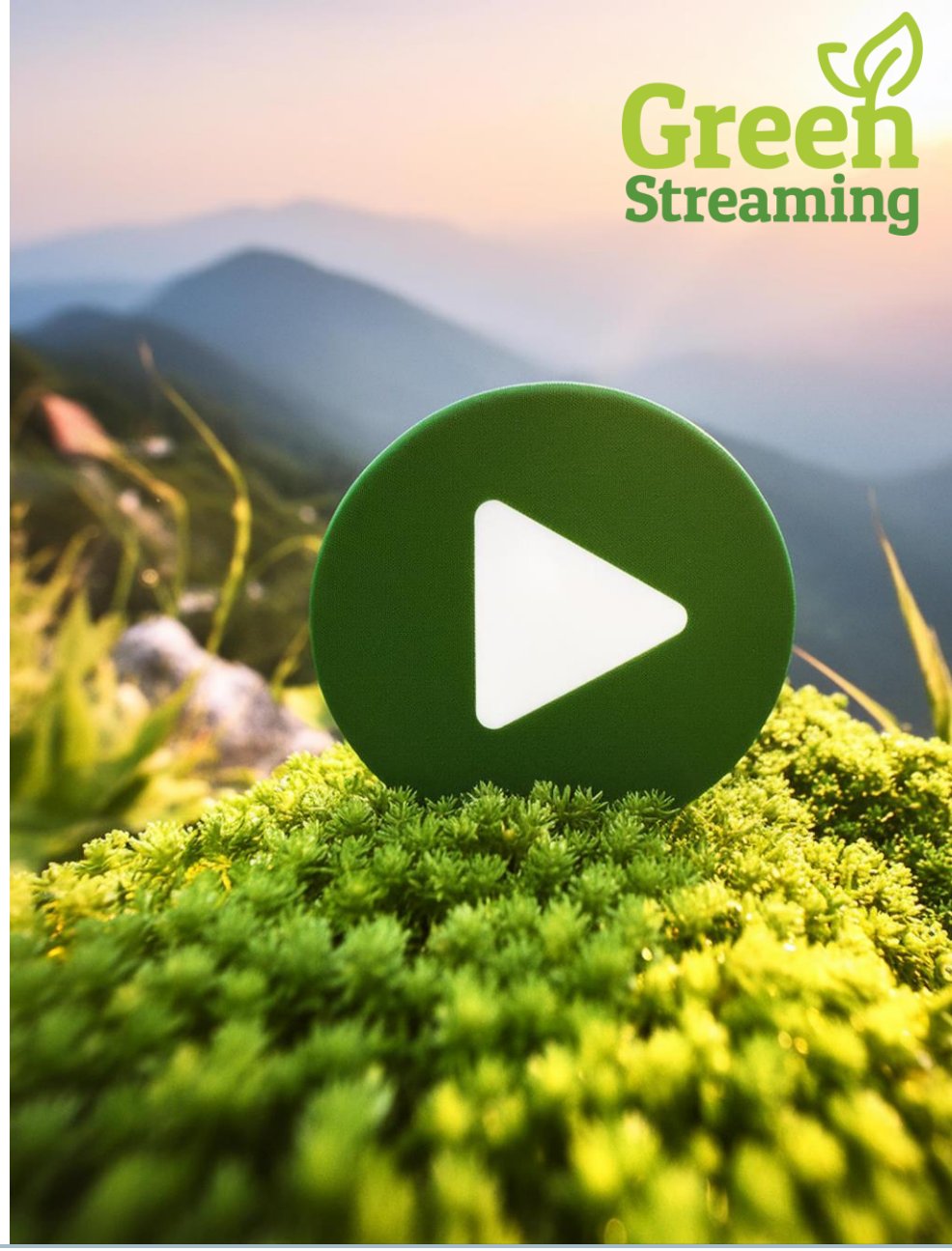
Conclusion and outlook

- Understanding the problem
  - End-to-end video streaming workflows are complex
  - Measurement is key! Automation is a must → FAMIUM Green Streaming Measurement Framework
- “Energy APIs” are missing
  - Improvements require moree advanced information of components and devices
    - Device settings / display settings etc.
  - HbbTV could play an important role to define and establish energy related device APIs
- Collect and learn from the data
  - Explore measurement data & build models
  - Fraunhofer FOKUS is working on green digital twins to model and predict energy consumption of streaming supply chain components
- Act and lower energy consumption
  - Identify opportunities → Luma reduction, energy modes, device APIs
  - Provide tools and recommendations
    - FAMIUM GreenView → “dynamic client-side adjustment of presentation of video streams for energy-saving playback”
- There is a need for collaboration of all involved parties in the value chain.



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Thanks for your attention!

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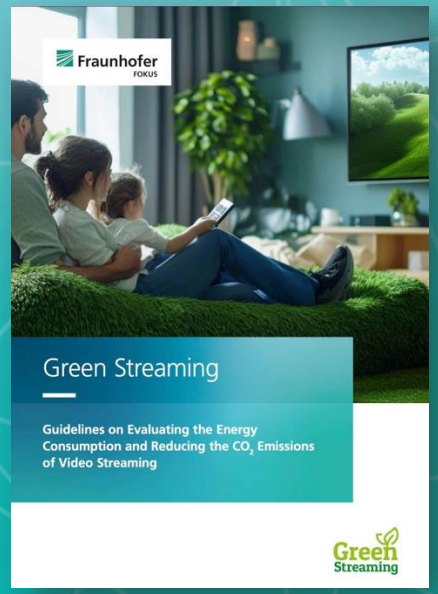

www.green-streaming.de