Fraunhofer FOKUS

HbbTV Symposium 2024
London

Fraunhofer FOKUS Institute for Open Communication Systems

Green Streaming decoded: Myths and Reality

Robert Seeliger [robert.seeliger@fokus.fraunhofer.de]

Green Streaming Project Scope

Partner

Fraunhofer FOKUS

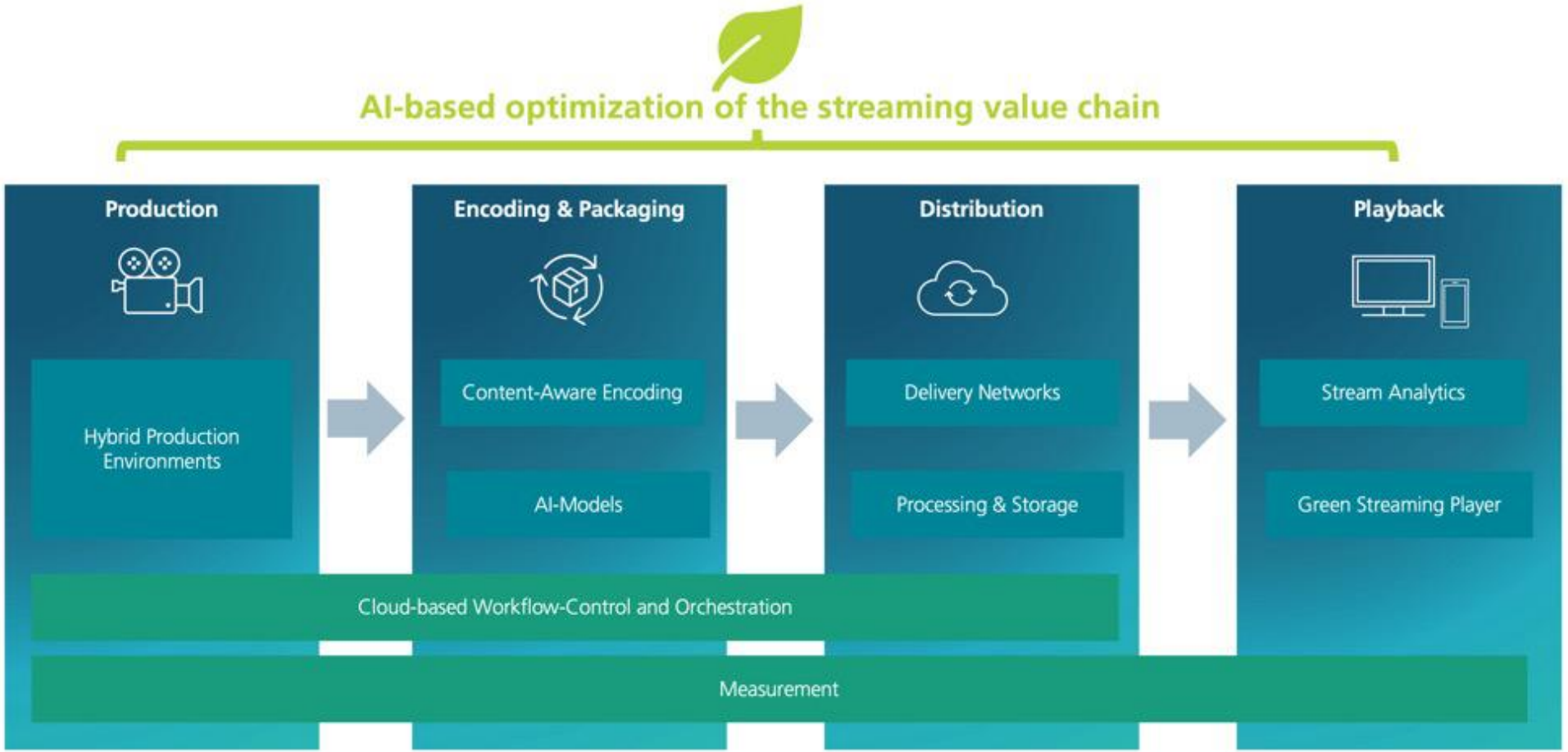
T · · ·

rbb

LOGIC FAIRNESS & KOMPETENZ

KlimAktiv

DEEP VA



Assoziierte Partner

RTL

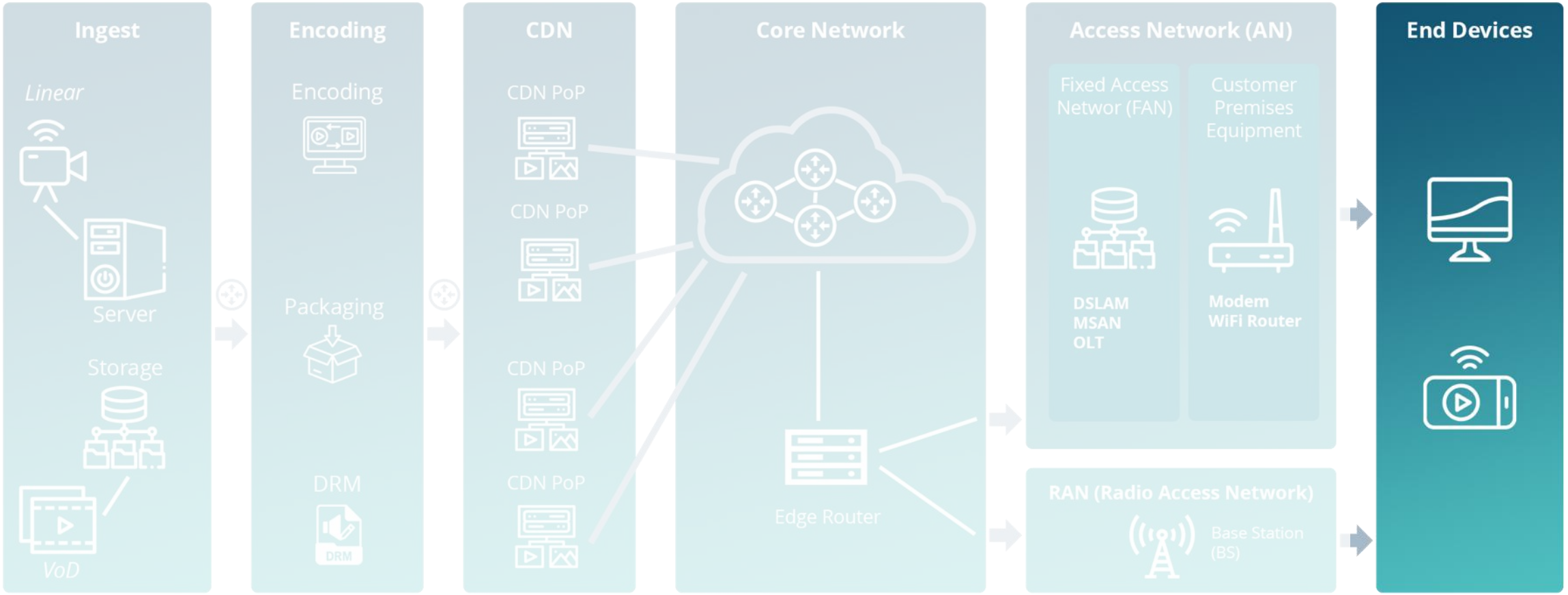
ZATTOO

arte

BITMOVIN

G & L

Streaming supply chain

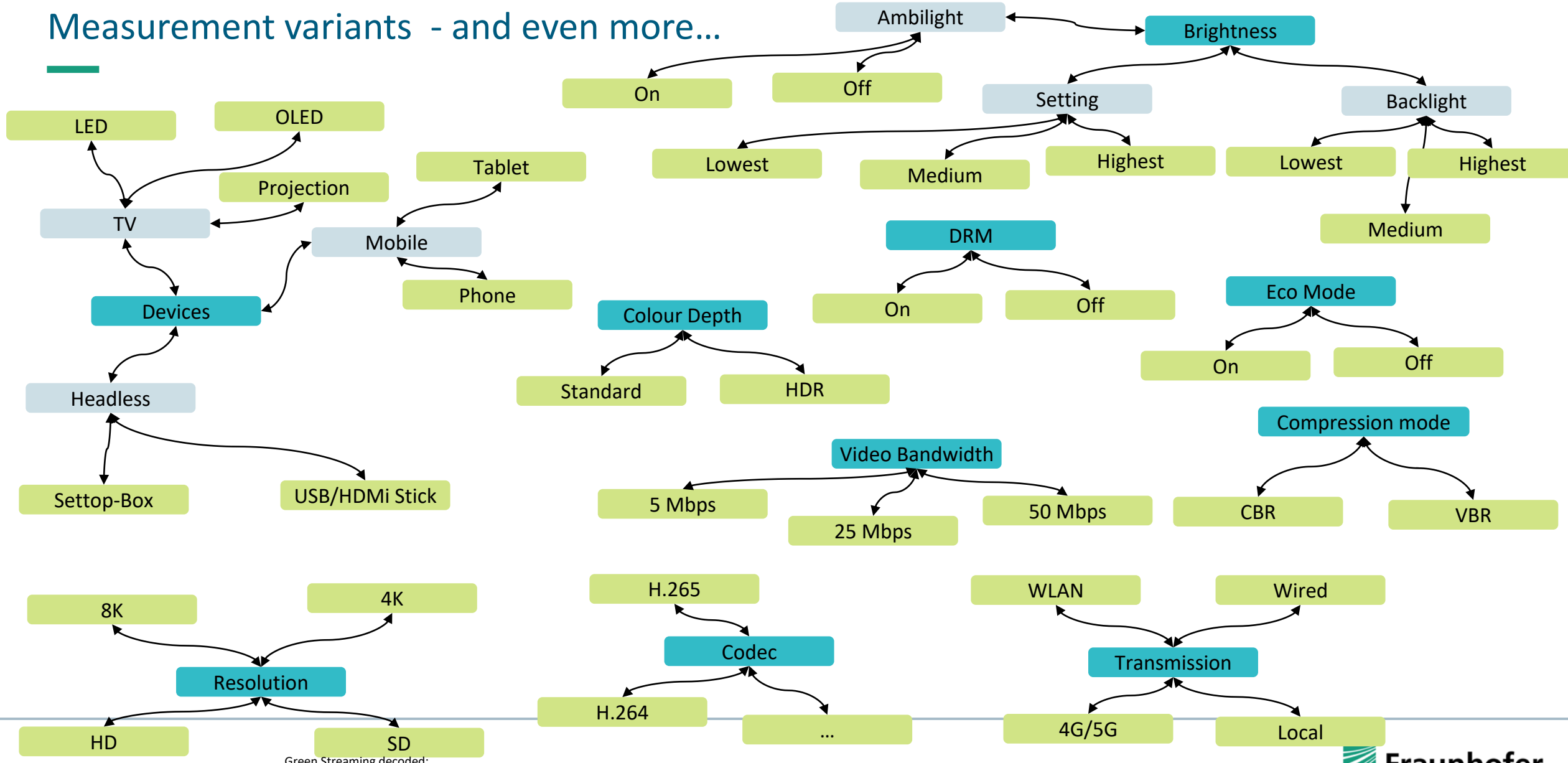


Fraunhofer FOKUS

Device Measurements

Nov 14, 2024

Measurement variants - and even more…



Fraunhofer FOKUS

Our approach

End-Device Measurement

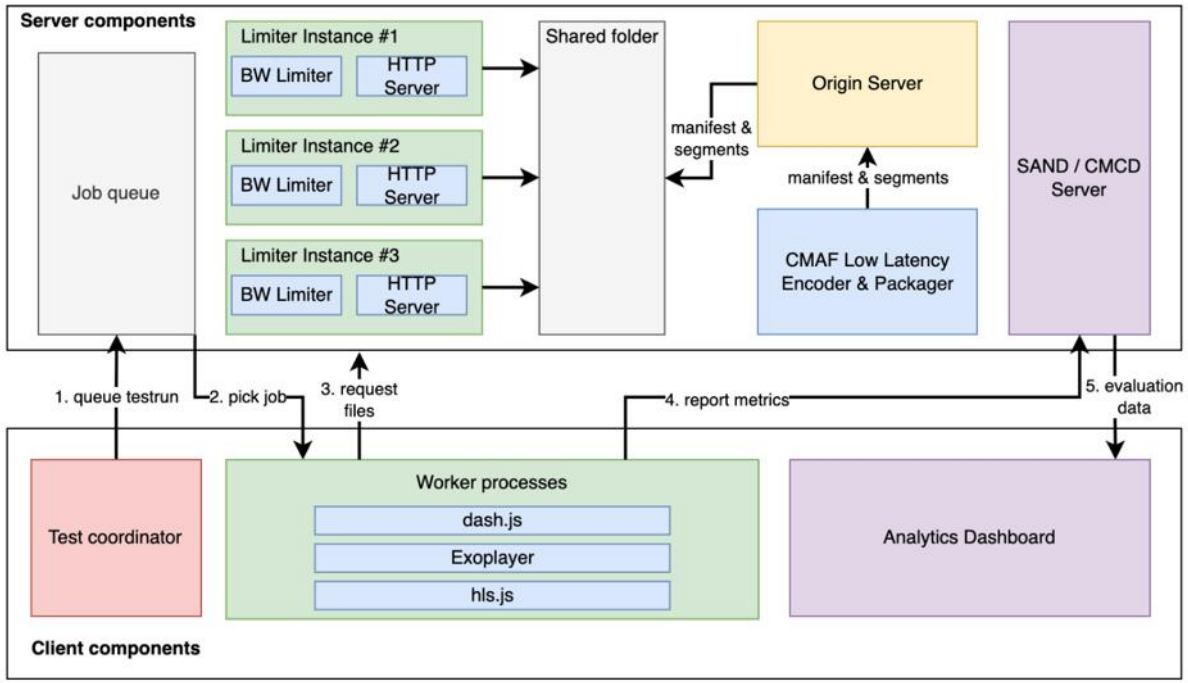
- ***How*** we want to measure?
  - controlled, synchronized, automated
  - combining energy measurements (real-time power meter data) with streaming session data and all relevant attributes

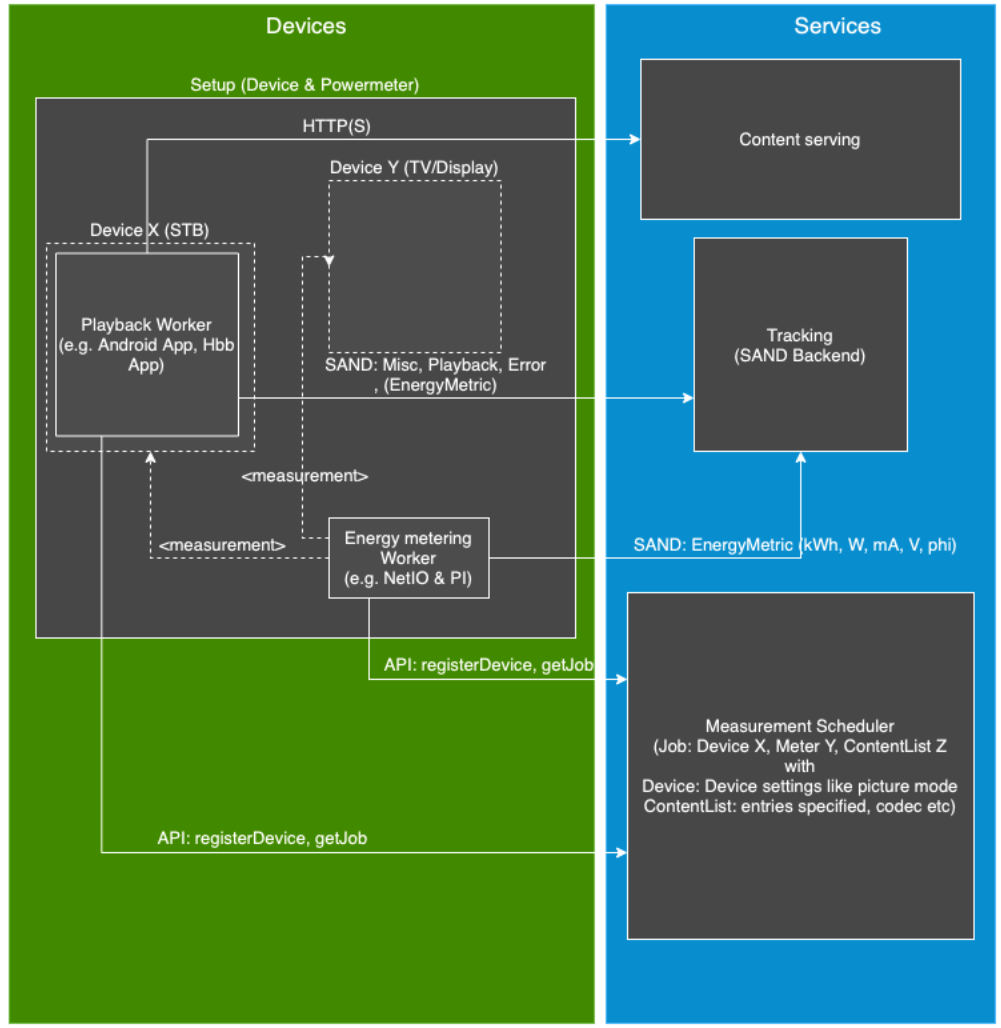
- ***What*** we want to measure?
  - *Attribute Triplet* comprising of
    - **Content Attributes** (complexity, luma, color histograms, codec, frame-rate, gop size, encryption, container, packaging, …)
    - **Device Attributes** (display technology, brightness level, stationary/mobile, light conditions,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

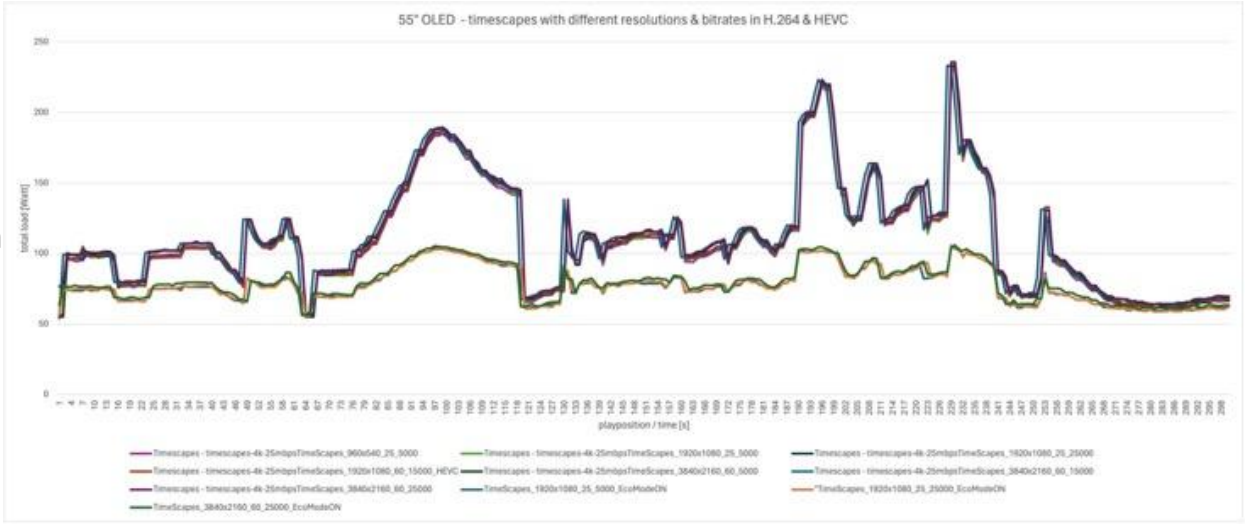
Architecture overview





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.



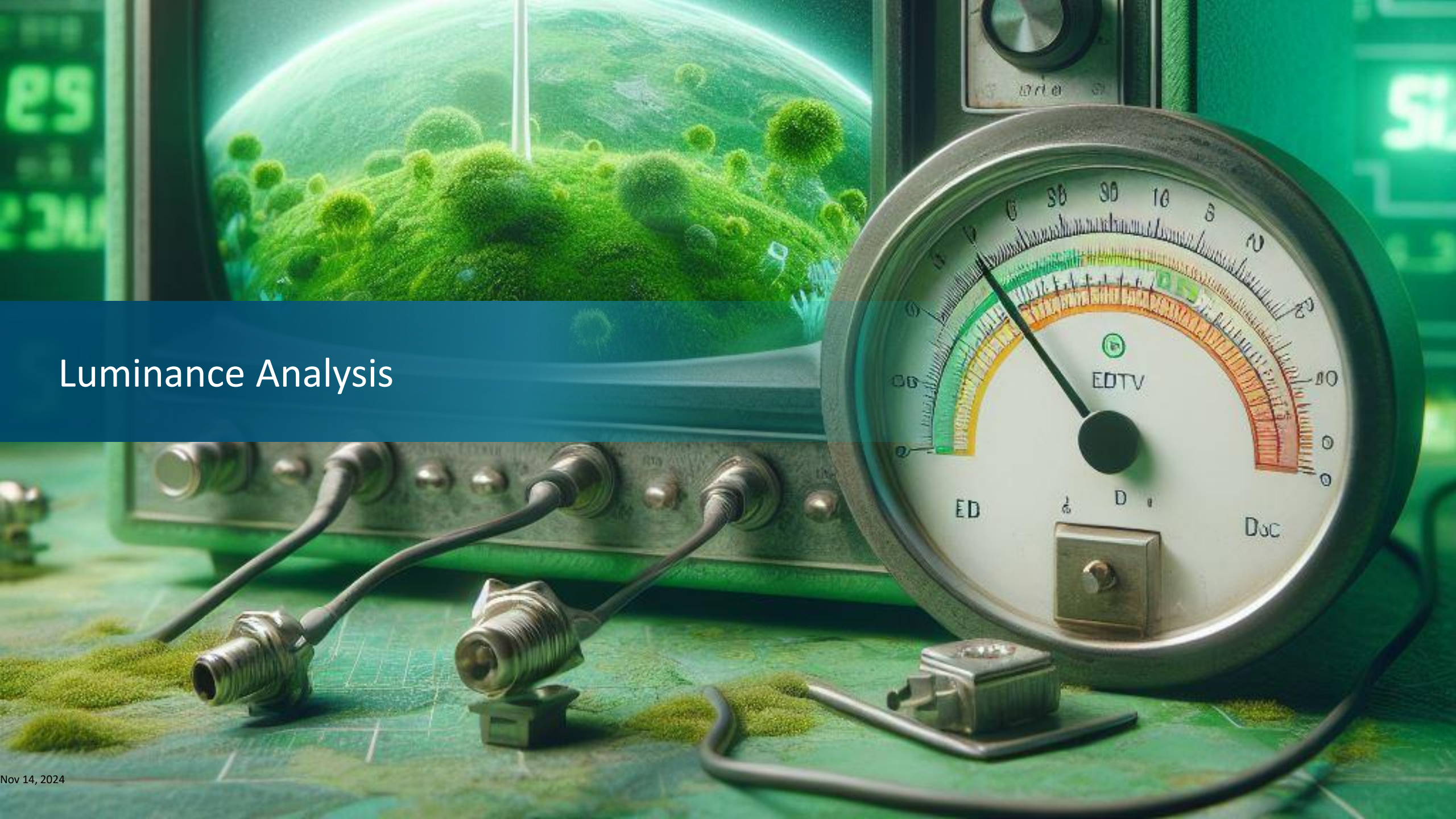
Key findings:

- 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	

Fraunhofer FOKUS

Luminance Analysis

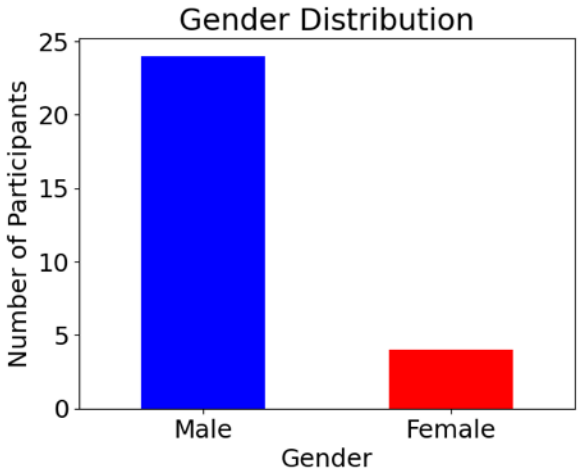


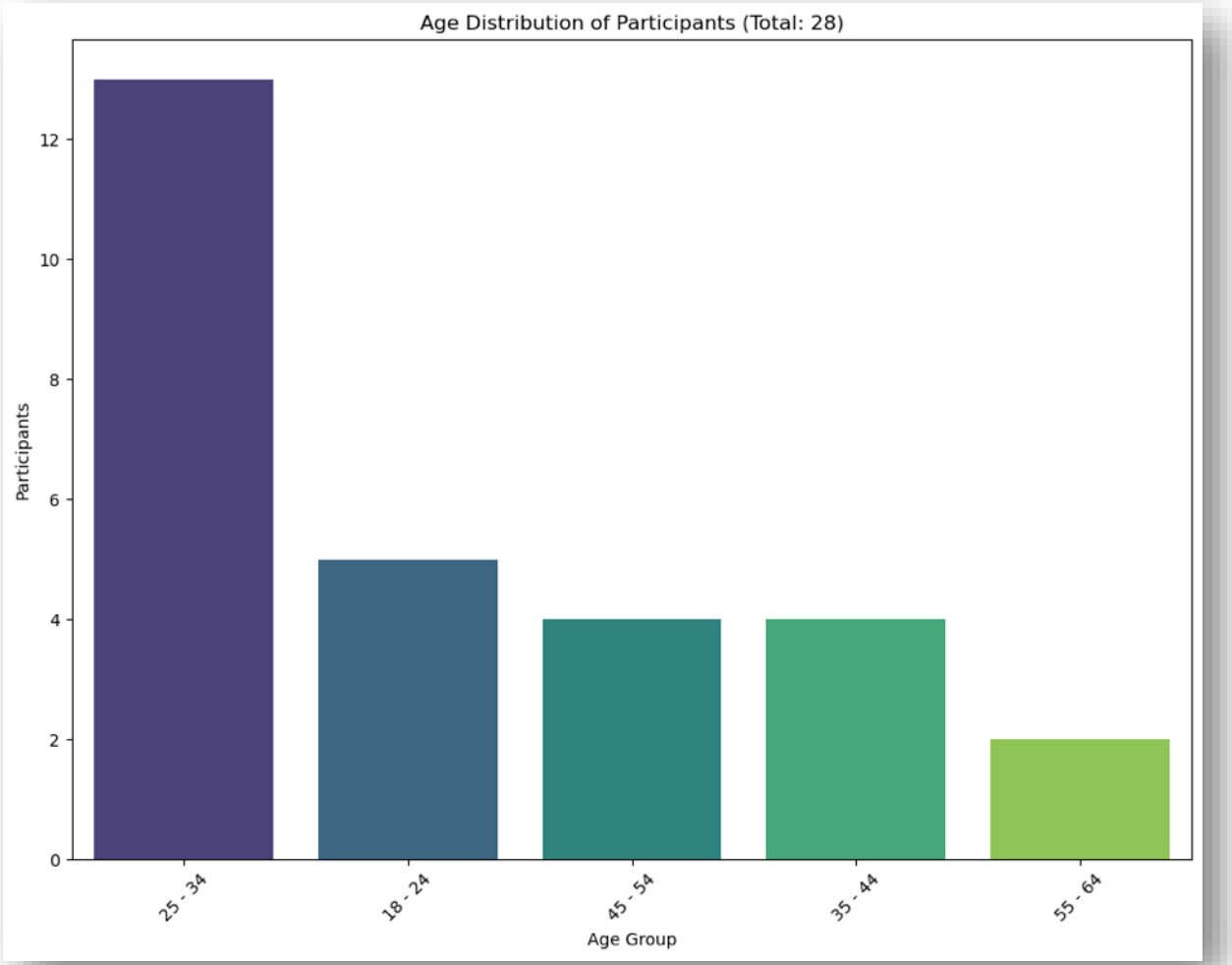
Nov 14, 2024

Experimental Setup and Participants

- OLED TV 55” 4K
- ITU - BT.500 Recommendation for test room
- Double Stimulus
- Participants from Fraunhofer FOKUS
- MOS measurements (on a scale of 1 to 5)

The Mean Opinion Score (MOS) is a numerical measure of the human-judged overall quality of an experience.





Fraunhofer FOKUS

Results

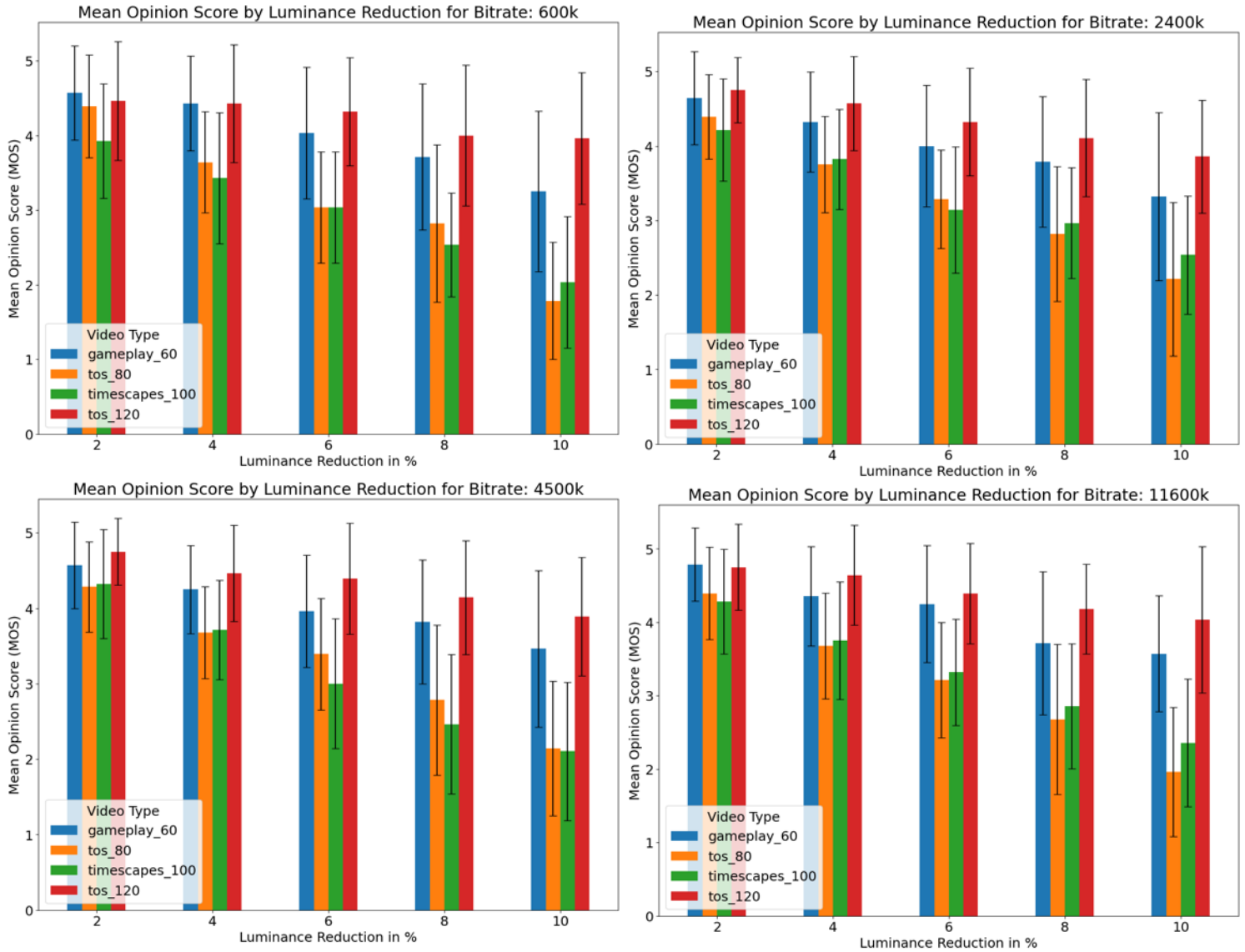
Subjective Score

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

- 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 significantly affect the energy consumption (especially on OLED TVs)

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



Fraunhofer FOKUS

FAMIUM GreenView

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

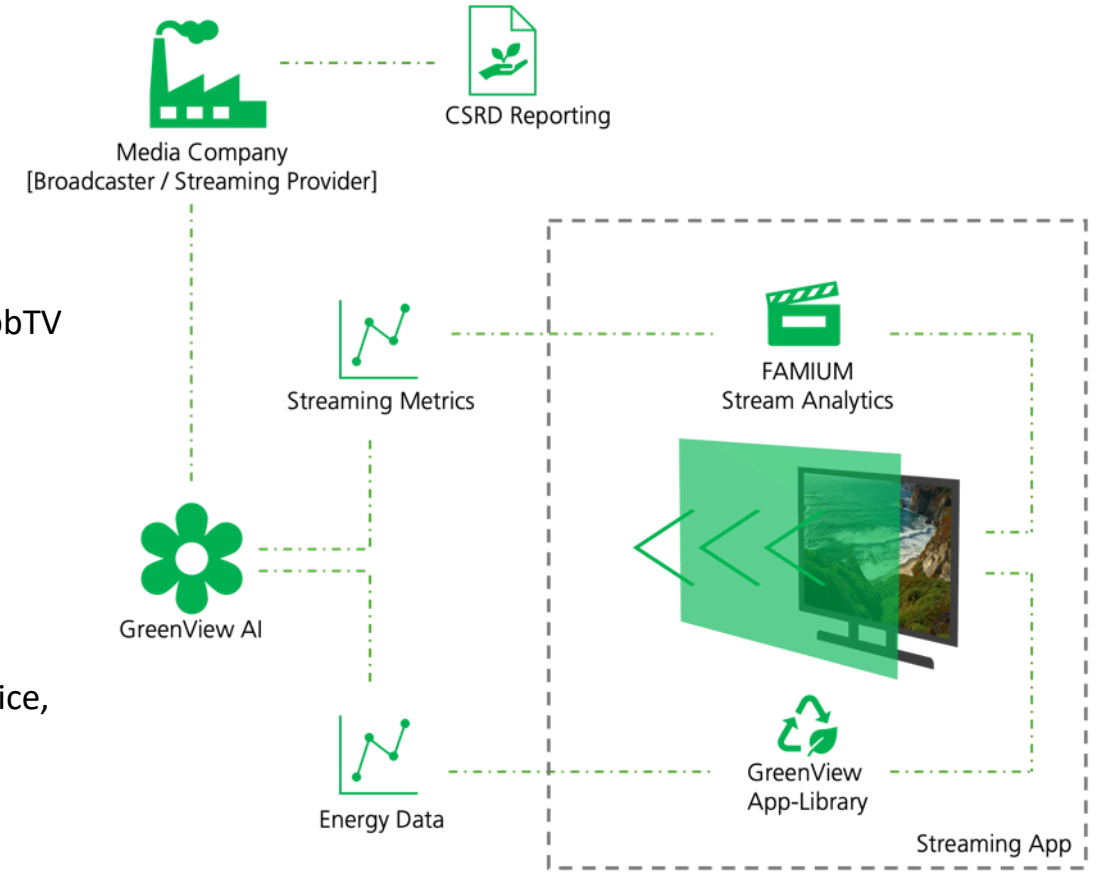
- Integration of a client-side library into streaming service applications.
- Backend component provides customized settings for each streaming session.
- Utilizes AI model to adjust streaming parameters based on context (content, device, display type) for optimal energy efficiency.

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.

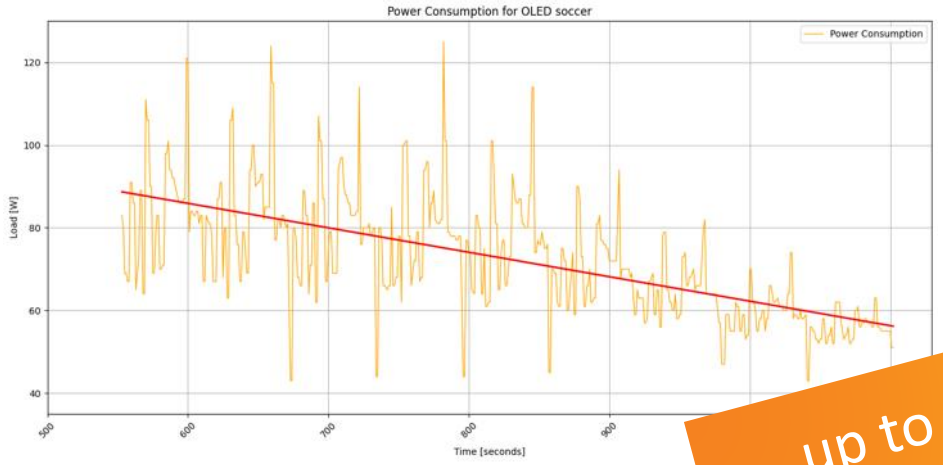
Compatibility and Accessibility

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

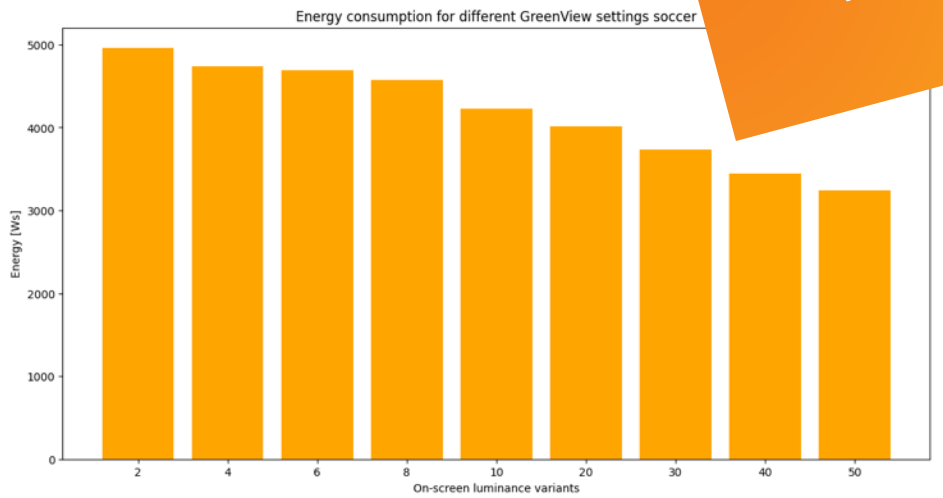


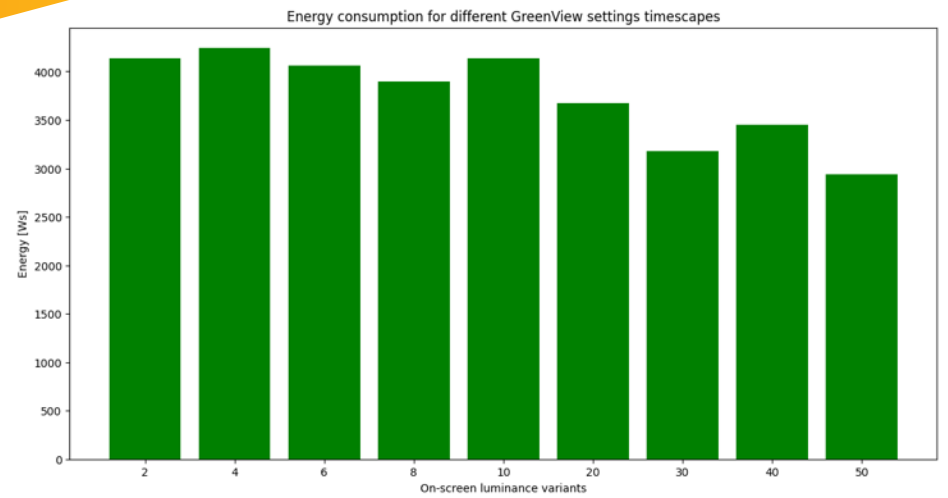
Fraunhofer FOKUS

GreenView enabled Energy Savings



up to 15-20% energy savings

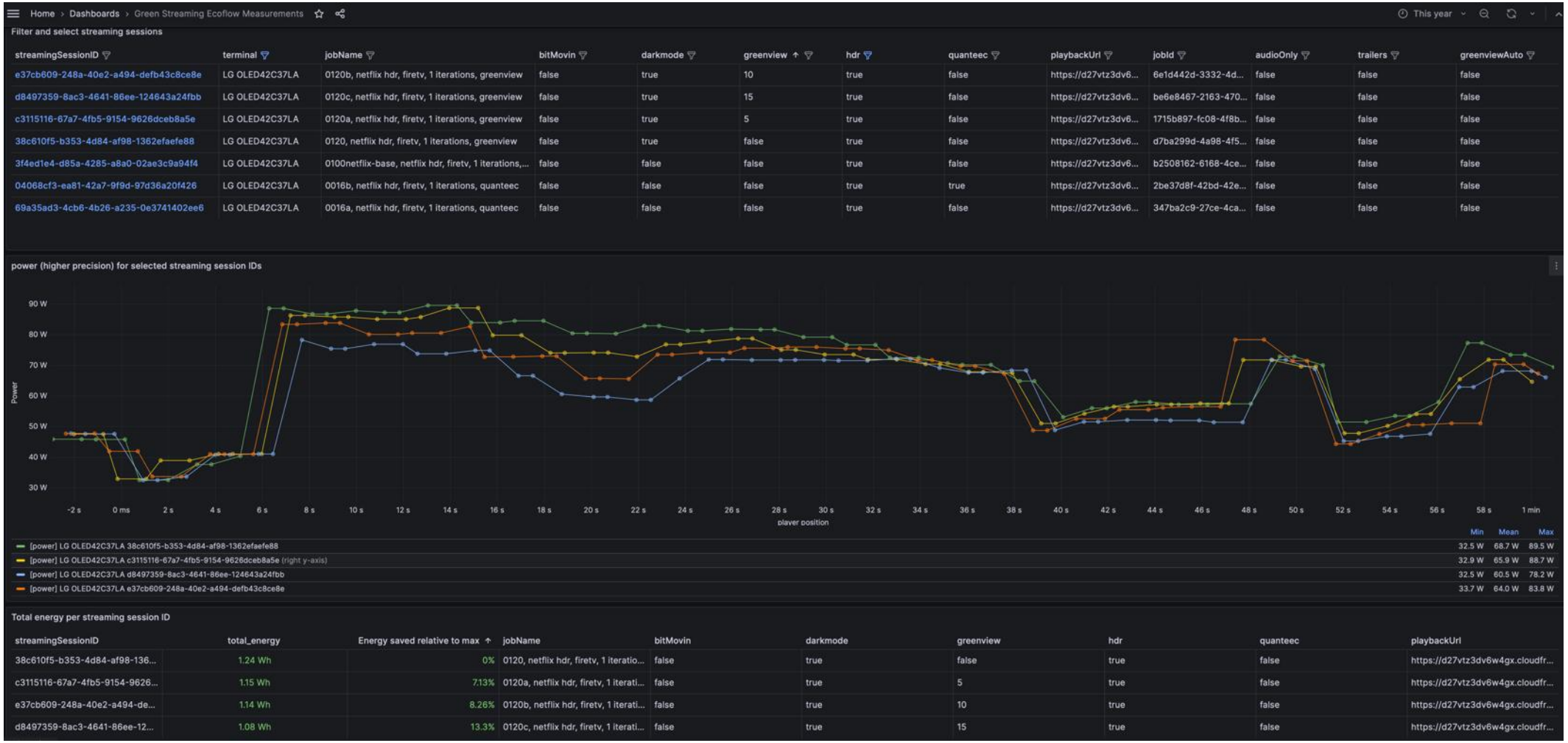




Fraunhofer FOKUS

Utilizing the Green Streaming Measurement Framework

GreenView Dashboard



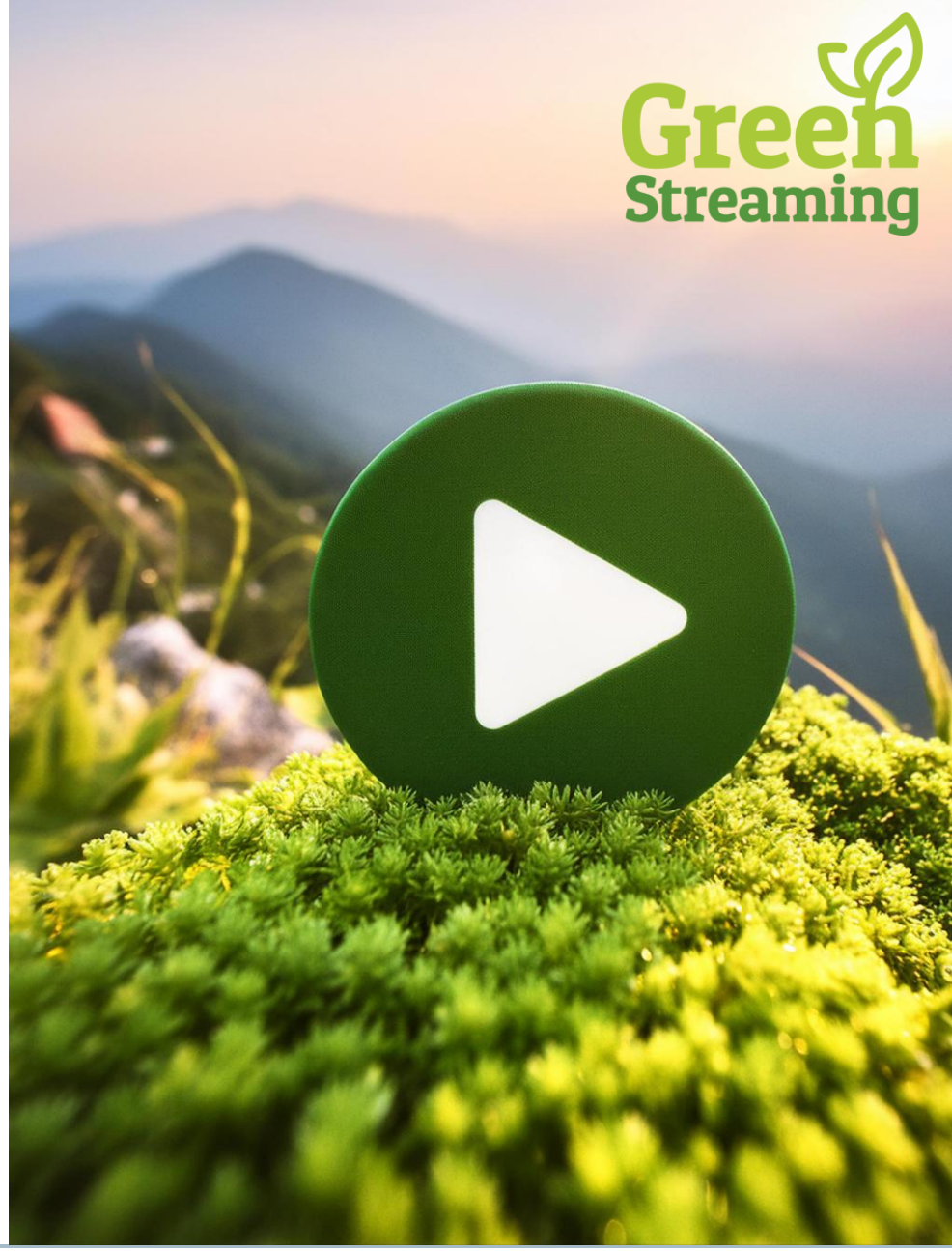
streamingSessionID	terminal	jobName	bitMovin	darkmode	greenview	hdr	quanteec	playbackUrl	jobId	audioOnly	trailers	greenviewAuto
e37cb609-248a-40e2-a494-defb43c8ce8e	LG OLED42C37LA	0120b, netflix hdr, firetv, 1 iterations, greenview	false	true	10	true	false	https://d27vtz3dv6...	6e1d442d-3332-4d...	false	false	false
d8497359-8ac3-4641-86ee-124643a24fbb	LG OLED42C37LA	0120c, netflix hdr, firetv, 1 iterations, greenview	false	true	15	true	false	https://d27vtz3dv6...	be6e8467-2163-470...	false	false	false
c3115116-67a7-4fb5-9154-9626dceb8a5e	LG OLED42C37LA	0120a, netflix hdr, firetv, 1 iterations, greenview	false	true	5	true	false	https://d27vtz3dv6...	1715b897-fc08-4f8b...	false	false	false
38c610f5-b353-4d84-af98-1362efaefe88	LG OLED42C37LA	0120, netflix hdr, firetv, 1 iterations, greenview	false	true	false	true	false	https://d27vtz3dv6...	d7ba299d-4a98-4f5...	false	false	false
3f4ed1e4-d85a-4285-a8a0-02ae3c9a94f4	LG OLED42C37LA	0100netflix-base, netflix hdr, firetv, 1 iterations,...	false	false	false	true	false	https://d27vtz3dv6...	b2508162-6168-4ce...	false	false	false
04068cf3-ea81-42a7-9f9d-97d36a20f426	LG OLED42C37LA	0016b, netflix hdr, firetv, 1 iterations, quanteec	false	false	false	true	true	https://d27vtz3dv6...	2be37d8f-42bd-42e...	false	false	false
69a35ad3-4cb6-4b26-a235-0e3741402ee6	LG OLED42C37LA	0016a, netflix hdr, firetv, 1 iterations, quanteec	false	false	false	true	false	https://d27vtz3dv6...	347ba2c9-27ce-4ca...	false	false	false

	Min	Mean	Max
[power] LG OLED42C37LA 38c610f5-b353-4d84-af98-1362efaefe88	32.5 W	68.7 W	89.5 W
[power] LG OLED42C37LA c3115116-67a7-4fb5-9154-9626dceb8a5e (right y-axis)	32.9 W	65.9 W	88.7 W
[power] LG OLED42C37LA d8497359-8ac3-4641-86ee-124643a24fbb	32.5 W	60.5 W	78.2 W
[power] LG OLED42C37LA e37cb609-248a-40e2-a494-defb43c8ce8e	33.7 W	64.0 W	83.8 W

streamingSessionID	total_energy	Energy saved relative to max	jobName	bitMovin	darkmode	greenview	hdr	quanteec	playbackUrl
38c610f5-b353-4d84-af98-136...	1.24 Wh	0%	0120, netflix hdr, firetv, 1 iteratio...	false	true	false	true	false	https://d27vtz3dv6w4gx.cloudfr...
c3115116-67a7-4fb5-9154-9626...	1.15 Wh	7.13%	0120a, netflix hdr, firetv, 1 iterati...	false	true	5	true	false	https://d27vtz3dv6w4gx.cloudfr...
e37cb609-248a-40e2-a494-de...	1.14 Wh	8.26%	0120b, netflix hdr, firetv, 1 iterati...	false	true	10	true	false	https://d27vtz3dv6w4gx.cloudfr...
d8497359-8ac3-4641-86ee-12...	1.08 Wh	13.3%	0120c, netflix hdr, firetv, 1 iterati...	false	true	15	true	false	https://d27vtz3dv6w4gx.cloudfr...

Conclusion and outlook

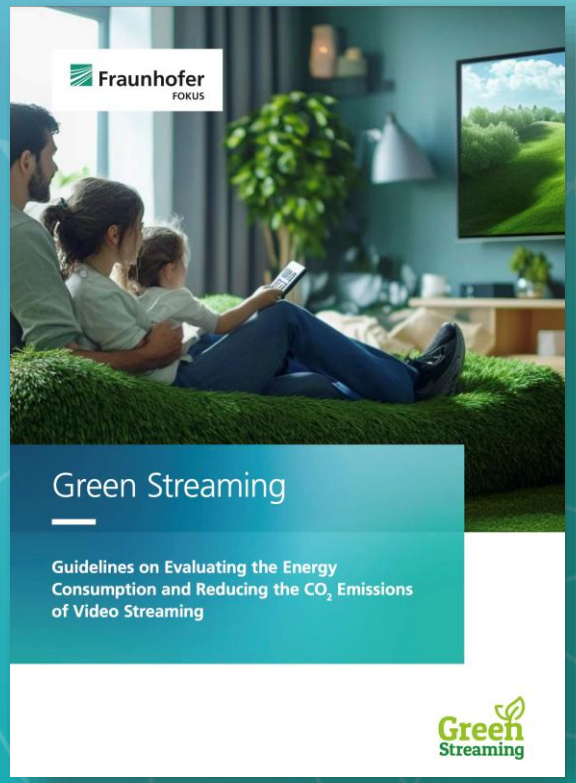
- Understanding the problem
  - End-to-end video streaming workflows are complex
  - Measurement is key! Automation is a must → FAMIUM Green Streaming Measurement Framework
- Collect and learn from the data
  - Explore measurement data & build models
  - Validate or falsify common assumptions
    → early example: Bitrate does *not* have a major effect on the energy consumption when streaming on a SmartTV. Same for resolution (Upscaling low res can have costs!)
- Act and lower energy consumption
  - Identify opportunities → Luma reduction, energy modes
  - 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.



Thanks for your attention!

Robert Seeliger
Video Sustainability Lead & Senior Project Manager Future Applications and Media
robert.seeliger@fokus.fraunhofer.de
Fraunhofer FOKUS
Berlin, Germany

Fraunhofer FOKUS



www.green-streaming.de