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EMPOWERING CONTENT EVERYWHERE

# IBC2025 Accelerators Programme

# ECOFLOW II: Impactful Technologies

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The rapid growth of streaming technologies has revolutionized the way people access and consume media, making video and audio content available on demand across the globe[1,2]. However, this digital transformation has also raised concerns about the environmental footprint of streaming, as the ecosystem supporting these services - data centres, networks, and end-user devices - consumes significant amounts of energy and contributes to global greenhouse gas emissions. Recent estimates suggest that streaming media is responsible for 3-4% of the global carbon footprint, a figure comparable to that of the aviation industry[3].

Despite these challenges, the streaming industry is increasingly embracing innovative technologies and sustainable practices aimed at reducing its environmental impact. Advancements such as energy-efficient data centres, the use of renewable energy, optimized content delivery networks (CDNs), and improved video compression algorithms are helping to lower the carbon emissions associated with streaming services. Furthermore, some organizations are promoting eco-friendly business policies and educating users about sustainable streaming habits[4].

This report explores the positive environmental impacts of emerging technologies in streaming, highlighting how industry leaders and new innovations are paving the way for a more sustainable digital future. By examining current strategies and future opportunities, this work aims to demonstrate that technological advancement and environmental stewardship can go hand in hand, ensuring that the benefits of streaming do not come at the expense of the planet[5].

The IBC Accelerator and its members are embracing positive environmental initiatives in streaming because they recognize the urgent need to reduce the sector's energy consumption, aligning with broader industry and societal goals for sustainability. The members involved include Accedo, Bouygues Telecom, Bitmovin, BT, Channel 4, DIMPACT, EBU, Greening of Streaming, Humans Not Robots, IET, ITV and Quanteec. By collaborating across the streaming ecosystem - including broadcasters, technology vendors, and sustainability organizations - they aim to develop standardized metrics and best practices for measuring and minimizing the environmental impact of the distribution of streaming workflows.

Building on the exploratory first phase of ECOFLOW, the project aims to establish standardised methods for measuring streaming's energy consumption, and identify energy-saving opportunities throughout the technology supply chain.

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1 https://greenly.earth/en-gb/blog/industries/whats-the-environmental-impact-of-streaming

2 https://www.carbontrust.com/our-work-and-impact/guides-reports-and-tools/carbon-impact-of-video-streaming

3 https://tech.eu/2023/11/15/the-environmental-impact-of-audio-and-video-streaming/

4 https://mainstreaming.com/blog/green-streaming-how-ott-services-can-help-save-the-planet

5 https://mainstreaming.com/blog/green-streaming-how-ott-services-can-help-save-the-planet

This phase shifts the focus from user devices to the IP distribution network, from origin server to receiving device. Specifically, the aim is to enable more reliable and comparable assessments of how different infrastructure choices affect energy consumption.

Initiatives like the ECOFLOW and ECOFLOW II projects exemplify this commitment, focusing on consolidating energy consumption metrics across the entire streaming supply chain, from content delivery networks to end-user devices, and identifying opportunities for efficiency gains.

Members are motivated not only by regulatory pressures and corporate responsibility, but also by the realization that collaborative innovation can drive meaningful change, enabling the industry to meet ambitious sustainability targets whilst continuing to deliver high-quality streaming experiences. In this report we summarize the contributions of some members and how they contribute to a more efficient future. This collective approach ensures that the benefits of technological advancement are balanced with environmental stewardship, setting a blueprint for a greener digital future.

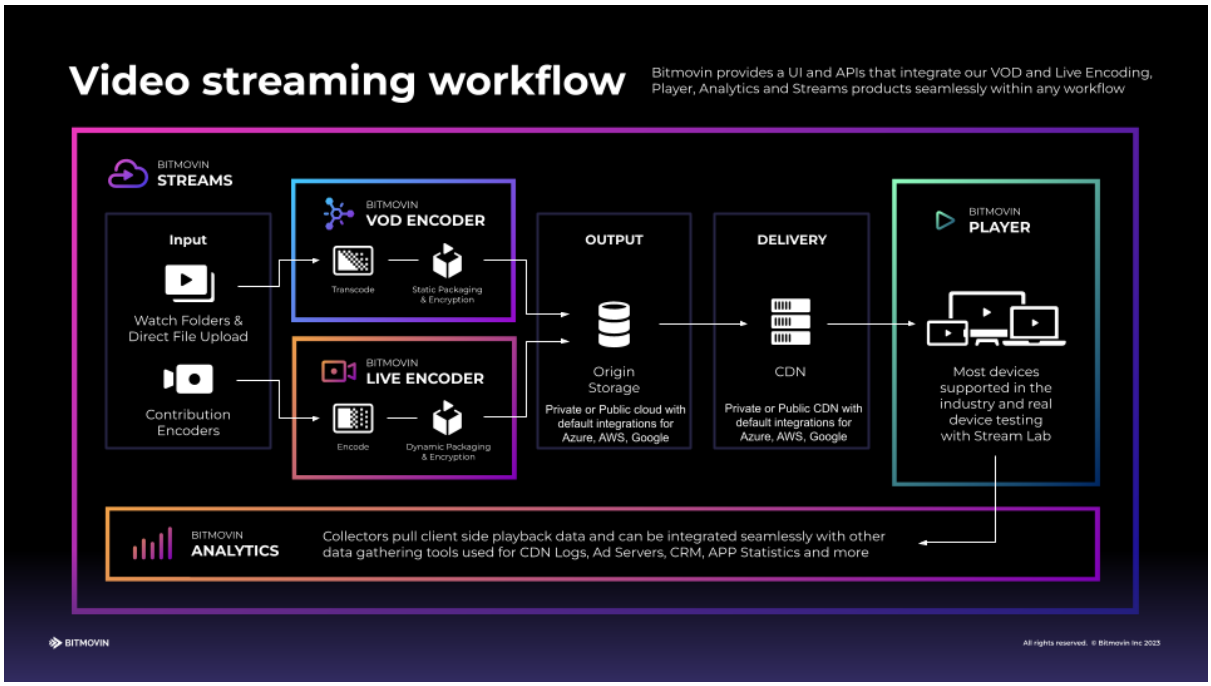
# Bitmovin

Founded in 2013, Bitmovin provides best-in-class VOD transcoding, live event encoding, client-side players, and video analytics designed and optimized for large streaming services. Our products are fully interoperable with the video and technology ecosystem to ensure easy and modular implementation for customers and partners.

## Impactful Tech

- Video player - plays video on all devices including TVs, CTV, consoles, browsers, mobile etc. Includes APIs and configurations for manipulating playback & CDN requests/responses e.g. HTTP headers. Our video player supports the evaluation of sustainable technologies by configuring custom settings e.g. CDN, rendition, UI and is pre-integrated with solutions like Quanteec & Fraunhofer GreenView.
- Video analytics - collects data about video playback and usage. Can be used for impact analysis e.g. to understand the % of users who have each device type or total hours watched using different sustainable technologies.
- VOD Encoding - processes pre-recorded video content for on-demand delivery, optimizing it for various devices and network conditions. It features advanced capabilities like Per-Title, Per-Shot, and Multi-Pass encoding for superior quality at lower bitrates, reducing storage and CDN costs. This cloud-native solution scales dynamically, leveraging the latest server generations and supporting multi-cloud deployments, contributing to sustainable practices by optimizing resource usage and reducing overall carbon footprint compared to traditional methods.
- Live Encoding - enables real-time processing and delivery of live video streams with high quality and resilience. It supports various input protocols, adaptive bitrate streaming, and multi-codec output (H.264, H.265, VP9), ensuring broad device compatibility. Designed for scalability across major cloud environments, it offers flexible deployment and cost-efficient scaling for events of any size, including out-of-the-box monetization with SCTE-35 support and instant Live-to-VOD content generation.

In the IP distribution workflow we focus on video encoding, video playback & playback analytics.




## Our Achievements

In ECOFLOW I, we provided the video player and supported the configuration of the ECOFLOW sustainable UI within the demo app.

We have a cooperative project with the University of Klagenfurt. This project is called GAIA, and a number of papers have been published: https://athena.itec.aau.at/gaia/ In addition the ATHENA team created the COCONUT dataset: https://github.com/cd-athena/COCONUT

### COCONUT

The COCONUT paper presents a dataset for measuring the energy consumption of adaptive video streaming across devices, codecs, and playback settings. Using a multimeter-based testbed, the ATHENA team captured energy use during segment retrieval, decoding, and rendering. The dataset covers various codecs (AVC, HEVC, VP9, AV1), resolutions, and decoding modes. Results show major energy differences, with AV1 (software-decoded) consuming up to 4× more power. COCONUT supports future research in sustainable, energy-aware video streaming.

### E-WISH

E-WISH is an energy-aware ABR algorithm that extends WISH, implemented in Bitmovin players, by adding an energy cost to bitrate selection, considering throughput, buffer, quality, and device power usage. It adapts to buffer status and optimizes for both QoE and energy efficiency. Experiments using real DASH playback show that E-WISH improves QoE by up to 52% and reduces energy consumption by up to 12%, outperforming approaches like SARA, BBA-0, and WISH.

**Energy-aware streaming optimization**

Recent research introduces solutions for energy-efficient adaptive video streaming by optimizing bitrate ladder construction for both video-on-demand and live streaming scenarios. First approach, **ESTR**, proposes a content-aware method that selects spatial and temporal resolutions not just based on visual quality but also on decoding energy consumption. Instead of relying on a fixed bitrate ladder or always selecting the highest quality representation, **ESTR** analyzes each video to find the video representations that maintain visual quality while reducing decoding energy consumption. This approach can reduce energy consumption by up to 46%, with only a negligible 2.52% loss in compression efficiency compared to quality-centric methods like per-title encoding.

Building on this, **LiveESTR** extends the concept to live streaming by using lightweight machine learning models (i.e., Random Forest Classifier) and video complexity features to predict optimal encoding configurations in real time. The results show that the encoder and decoder energy consumption is reduced by 74.6% and 29.7%, respectively. The proposed methods offer practical strategies for sustainable and efficient video streaming.

Energy-Efficient Spatial and Temporal Resolution Selection for Per-Title Encoding

Real-Time Quality- and Energy-Aware Bitrate Ladder Construction for Live Video Streaming

**Multi-Dimensional Video Compression Dataset (MVCD)**

Optimizing video streaming for both quality and energy efficiency requires detailed insights into how different encoding configurations impact performance. To support this, we introduce **MVCD**, a large-scale dataset specifically designed to capture the relationships between video content, encoding parameters, and streaming energy consumption. **MVCD** includes over 4.7 million records that cover encoding and decoding energy consumption, processing time, bitrate, and video quality across a diverse set of videos, resolutions, framerates, codecs, and playback devices. This dataset enables training and benchmarking of machine learning models for applications such as rate-quality control, resource allocation, and energy-aware streaming.

MVCD: Multi-Dimensional Video Compression Dataset

**Sustainable encoding via preset selection**

To make video streaming more sustainable without sacrificing quality, this work explores the impact of encoder presets, settings that trade off encoding speed, compression efficiency, and energy consumption within the context of per-title encoding. The study evaluates the energy consumption and quality trade-offs of different x265 presets across 500 UHD video sequences. It shows that switching from the slowest preset to a content-optimized faster one can reduce encoding energy by up to 97% with only minor visual quality loss.

Optimizing Video Streaming for Sustainability and Quality: The Role of Preset Selection in Per-Title Encoding

## Green

We see that when inappropriate renditions are chosen, current intensity can be up to 4x greater. Specifically, when software decoding is used because a hardware decoder isn't available for the selected rendition. Using our Player to ensure that only appropriate renditions are chosen can avoid this increase in current intensity.

Measurements are calculated in the COCONUT dataset and the associated paper.

This is through a combination of measurements made by COCONUT and data from our Analytics product, which shows the number of devices playing video using different codecs.

# BT Group

BT Group plc is a British multinational telecommunications company headquartered in London. Operating in around 180 countries, and with around 100k employees, it is the UK's leading provider of fixed-line, broadband, mobile, and digital television services. BT also delivers secure digital products, IT services, and managed network infrastructure to global corporate and government clients. With major divisions including BT Business, BT International, BT Consumer, BT Digital, BT Networks (includes Applied Research) and Openreach, the company serves millions of customers. BT is the world's oldest telecoms company, and traces its origins to the Electric Telegraph Company in 1846 and has evolved into a key player in global communications, listed on the London Stock Exchange and part of the FTSE 100.

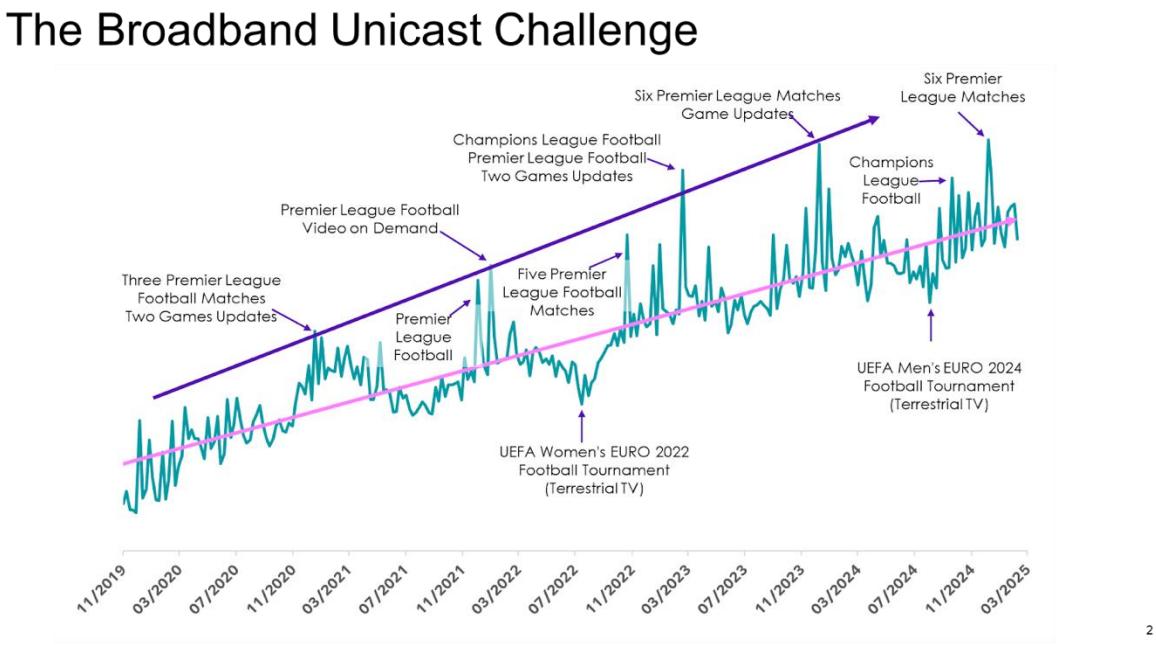
BT has been a pioneer in the development and delivery of digital television delivered over broadband, starting with the first trials in 1996 which evolved into the launch of their TV service which started in 2006. BT currently has well over one million TV customers, and is a steering board member of the DVB, and Council member of DTG, as well as being represented in other key industry fora such as SVTA.

As well as the consumer TV business, BT also has the B2B BT Media & Broadcast who provide contribution and distribution connectivity to many leading broadcasters, including distribution of Freeview to transmitter sites in the UK.

BT has a joint venture with WBD called TNT Sport (formerly BT Sport) which provides sports programming in the UK, including its own original content from football stadia and other sporting venues.

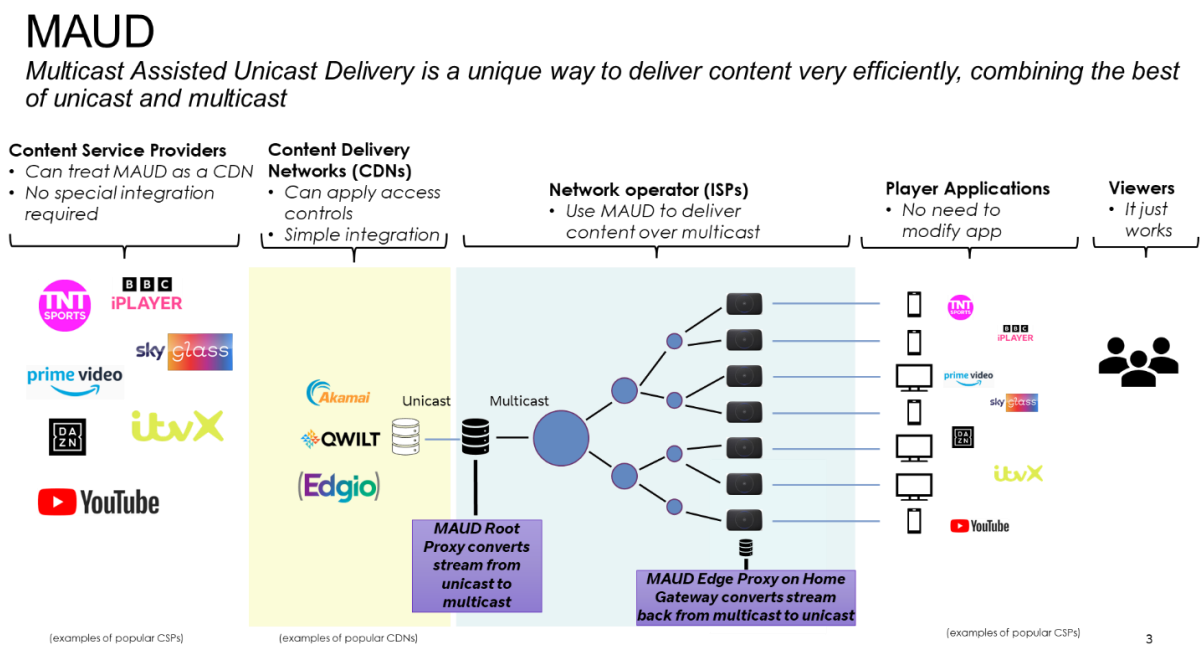
## MAUD

Broadcast delivery over the airwaves (where one transmitter efficiently serves the same stream to millions of viewers) is losing popularity in favour of broadband delivery (where typically each viewer has their own personal stream). This requires the delivery networks to be commissioned for peak demand of the resulting millions of separate streams, whilst much capacity is wasted at other times. This is inefficient in capex spend, and from an environmental viewpoint increases switch count (and therefore energy demand) proportionate to those peak loads.




The Live TV Network Challenge

Multicast Assisted Unicast Delivery (MAUD) is a technology developed by BT Applied Research that takes a third party's ABR unicast live TV stream from a CDN, tunnels it in a multicast pipe over the MSO's network, and converts it back to unicast in the home. It requires no changes to the content provider's head-end, nor any client changes, which means it is quickly and easily applied to a wider variety of sources and content providers. Critically it preserves individual client information presented to the streaming origin, allowing access control and targeted advertising to be used as normal.




BT's MAUD – Efficient Live TV Distribution over Broadband

## AutoSmart

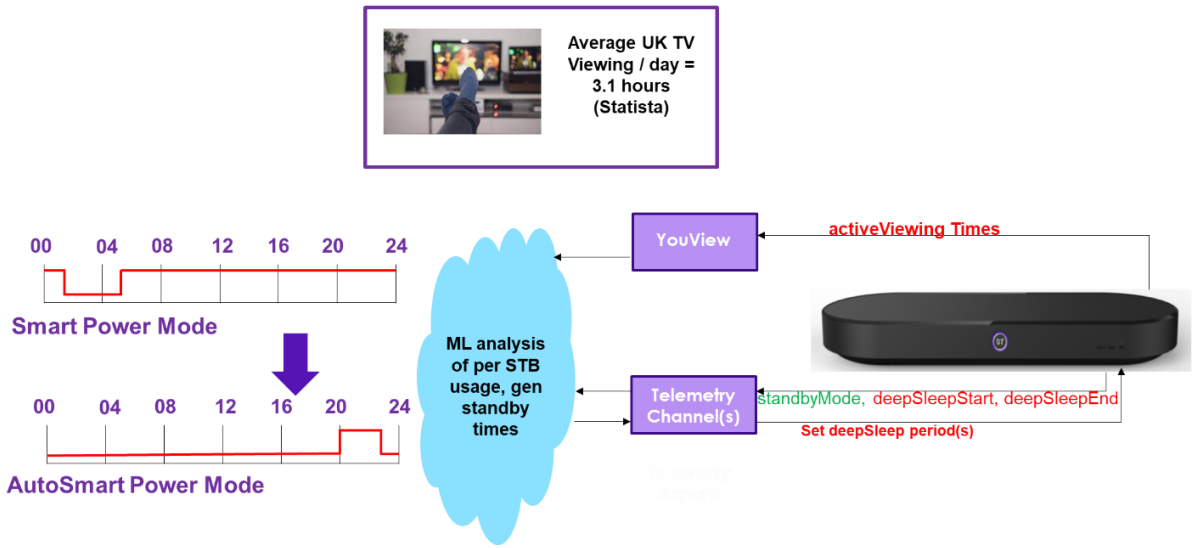
Set-top boxes (STBs) that deliver multi-channel live and on-demand programming into customers' homes have a number of different power modes depending on how they are being used. Deep sleep states consume the least energy, typically well under 1w, and are responsive to wake sources such as a remote control key press or incoming IP traffic (casting etc). The time taken to wake varies, but can be as much as 1-2 minutes. Conversely, a box that is fully awake (but with HDMI/LEDs switched off) will respond instantly to viewer demand, but can consume x10 or even x60 as much power.

Many devices therefore default to a deep sleep state during the period when they are least likely to be used, and an awake state at other times. With a sleep period of (for example) 01:00-05:00, the box will be fully on for 20 hours per day, despite the average UK viewer only watching just over 3 hours of content per day. This results in the box being on and unused for 17 hours per day.

Using machine learning, we can analyse the usage patterns of an individual box, and automatically adjust its deep sleep period to just outside the times of active use. This results in an energy saving of up to 80% via this "AutoSmart" method.

Depending on the "intelligence" of the ML, the sleep periods may not be perfectly adjusted for all users. For these cases, viewers are free to select non-AutoSmart power modes, still leaving a big increase in energy efficiency across the whole estate.

## From Smart to AutoSmart




BT's AutoSmart – Saving up to 80% of STB Energy Consumption

## Power Metering in STB SoC Chipsets

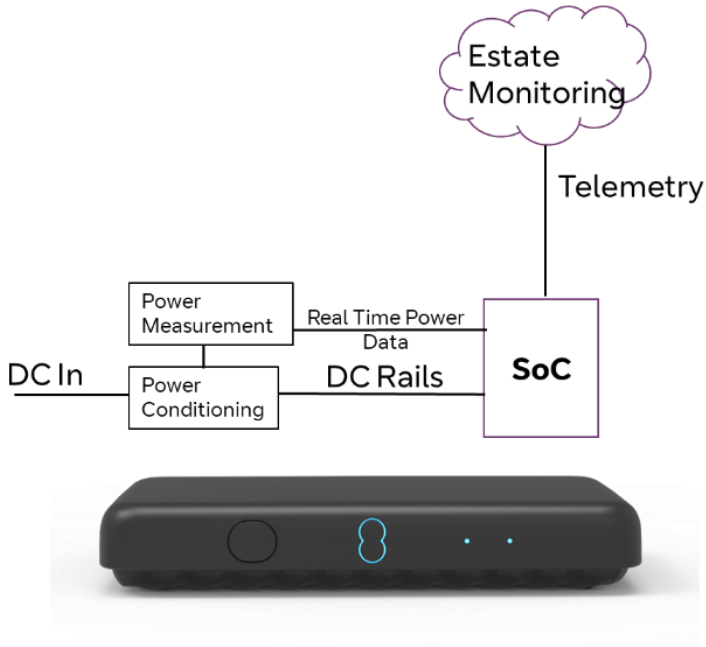
One of the challenges of calculating the environmental impact of TV service delivery, and quantifying any improvements made is accurately measuring the power consumption of devices.

Currently suppliers and operators typically take a lab-based sample approach:


Current Approach to Power Consumption Measurement:
Lab Sample Testing

Whilst an accurate one-off measurement, it may not capture the varying real-world conditions across the whole customer base, and is not a continuous measurement as players and service delivery methods change.

Newer Broadcom based streaming platforms have the built-in real world electrical monitors and the machine learning engines to intelligently optimize the platform power consumption and performance. Furthermore, they provide the mission critical building blocks for industry partners to develop and to deliver network wide energy saving solutions:




Future Approach to Power Consumption Measurement:
Real Time Data from Whole Estate

## Green

AutoSmart saves up to 80% of STB energy usage, calculated from active and deep sleep power figures across our estate.

MAUD reduces the amount of network equipment required to deliver peak demand, saving energy consumption in having fewer switches operating, and the energy that would have been used in manufacturing them.

Whole estate power consumption monitoring coupled with ML in the end consumer devices will drive a significant reduction in power consumption in STBs.

# Humans Not Robots (HNR)

HNR brings together Artificial Intelligence and Big Data, focusing on clean growth, to empower media and broadcast, telecom and gaming organisations to gain clear insight into three key consumption metrics across their operations - **environmental impact, cost** and **time** - how do I process content more efficiently whilst minimising impact?

Founded by industry veterans Kris Brown and Kristan Bullett, HNR is a remote-first start-up dedicated to providing workflow observability and analytics solutions that streamline digital operations, making them more cost-effective, faster and cleaner. Our mission at HNR is clear: **help data-heavy businesses operate *more efficiently and more sustainably.***

Our overarching goal is to significantly reduce the environmental impact of technology operations in data-heavy businesses by 30% within the next decade.

HNR was *e*stablished in 2021 and is headquartered in York, United Kingdom.

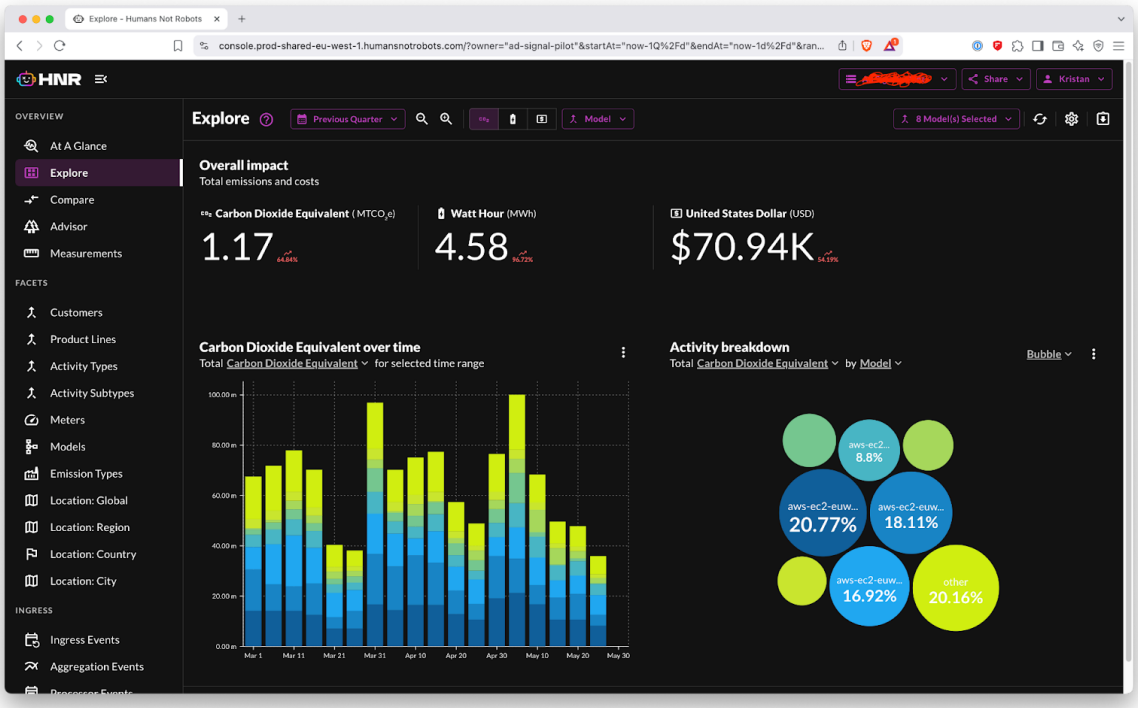
## Impactful Tech

**HNR** *to* ZERO is a Cost Knowledge, Application Observability and Analytics platform which measures, aggregates and enriches data from digital footprint. We are not a technology that directly reduces costs for a business's technology footprint and we are not video centric but support providing measurement, analysis and insight enabling our customers to confidently make changes and track changes that will reduce costs.

With *Greening of Streaming*, **HNR** *to* ZERO provides a telemetry service and measurement framework which allows for near real-time and granular power measurement using OpenTelemetry standards and Tapo Energy Monitoring plugs.

Other core platform features include scenario modelling and forecasting, facet mapping, attribute enrichment and apportionment modelling.

**HNR** *to* ZERO is not a video centric product but it does have a video specific context applied to it. With that said, **HNR** *to* ZERO's responsibility is to measure, enrich, aggregate and analyse data points within digital technology footprint. **HNR** *to* ZERO can therefore sit at every point within the linear IP distribution workflow.




## Our Achievements

- Greening of Streaming REM
- Austrian telco platform measurement
- ESA 5G-EMERGE platform measurement

## Green

We try to take “real” values where possible. This means using our collectors to receive power measurements from source be that via Tapo Energy Monitoring plugs with devices connected directly to them or through top-of-rack meters through IPMI.

We aim to get a relatively granular set of measurements from systems. For near real-time we look at measurement intervals of 20s and for non-real-time we recommend hourly measurements.

# Quanteec

Quanteec focuses on video streaming technologies and proposes P2P solutions for OTT platforms and corporates. Quanteec's solution absorbs audience spikes, increases viewers engagement, and delivers the best quality each device is capable of receiving while keeping costs low and reducing the need for servers-based infrastructures. The technology addresses current challenges of scalability, latency, and resource deployment related to video streaming platforms, as well as their rapid expansion.

## Impactful Tech

The tech is a P2P plugin allowing the viewers to contribute to the delivery. Instead of downloading the media data from the CDN, the viewers are able to share the data with each other. It is an added piece to the CDN. The goal is to reduce the number of servers deployed by reusing the existing resource and devices.

In a life cycle assessment (LCA) framework, the environmental impacts of CDNs occur throughout their entire lifecycle:

1. Manufacturing and deployment of servers: raw material extraction, electronic component production, transportation, and installation. The construction of hosting facilities should also be considered when opening new data centres.
2. Usage phase: electricity consumption of servers and cooling systems, with significant impact due to the chronic underutilization of infrastructure.
3. End-of-life: maintenance, equipment replacement, and electronic waste management/recycling.

In contrast, P2P technology does not rely on equipment dedicated specifically to video distribution. Instead, it optimizes the use of resources that have already been produced and deployed: the end users' devices.

## Our Achievements

Since the beginning, Quanteec has **displayed energy saving metrics to its clients** in the Quanteec back-office. Quanteec tries to communicate as much as possible on this aspect in order to convince others to take a look at the energy consumption of video streaming. The energy savings estimation has been modified regularly during the last years, following the fast moving SotA on the subject.

The impact of Quanteec is not always instantaneous, and is more long term, as it promises to reduce the actual number of cache servers deployed to deliver contents. For a more concrete achievement, Quanteec has been able to **reduce by 50% the number of servers** required to deliver the streams of a local webcam delivery platform.

## Green

At the beginning, the savings were estimated using the (in)famous Shift, IEA, and DImpact models. However, with the findings of Greening of Streaming, ECOFLOW, and other groups, these models were contested. As a consequence, the estimation made by Quanteec has been modified several times. The last iteration aims to compare the CDN usage (with the last available numbers) and the P2P additional consumption on the device.

To evaluate the energy benefits of P2P technology versus exclusive CDN usage, two series of experiments were conducted:

1. Measuring the electrical consumption of P2P data transmission in Wh across different device types.
2. Measuring battery discharge rates during P2P data transmission for battery-powered devices.

These experiments allowed us to quantify the energy consumption of devices during P2P data transmission and compare these values to the energy consumption of a CDN.

The transmission through P2P is **between 0.05 Wh/GB and 0.1 Wh/GB** depending on the device. This number is to be compared with the average energy consumed by a CDN to transmit 1 GB of video data: **0.43 Wh/GB**, according to the reference data from the October 2024 Arcom, Arcep, ADEME report.

With the current model, the achievable savings of Quanteec are around **100kWh** for a TV platform **during 24 hours** (**30k to 100k viewers**), and even more during important events.

The streaming industry stands at a critical juncture where technological innovation and environmental responsibility must move forward hand in hand. The initiatives highlighted throughout this paper - ranging from multicast assisted unicast delivery, observation and analytics platform to peer-to-peer delivery - demonstrate a clear commitment to reducing the sector's environmental impact. The proactive approach taken by organizations within the IBC Accelerator is instrumental in driving industry-wide change, fostering collaboration, and setting new standards for sustainability.

By embracing these positive environmental initiatives, the streaming ecosystem is not only mitigating its carbon footprint but also positioning itself as a leader in sustainable digital transformation. The collective efforts of broadcasters, technology providers, and sustainability experts underscore the importance of shared responsibility and innovation in addressing global environmental challenges.

Looking ahead, continued investment in research, cross-industry collaborations, and education will be essential to further minimize energy consumption and maximize the positive impact of streaming technologies. Ultimately, these endeavours ensure that the future of streaming is not only technologically advanced but also environmentally sustainable, benefiting both the industry and the planet.