The Sustainable Future of Video Entertainment

From creation to consumption

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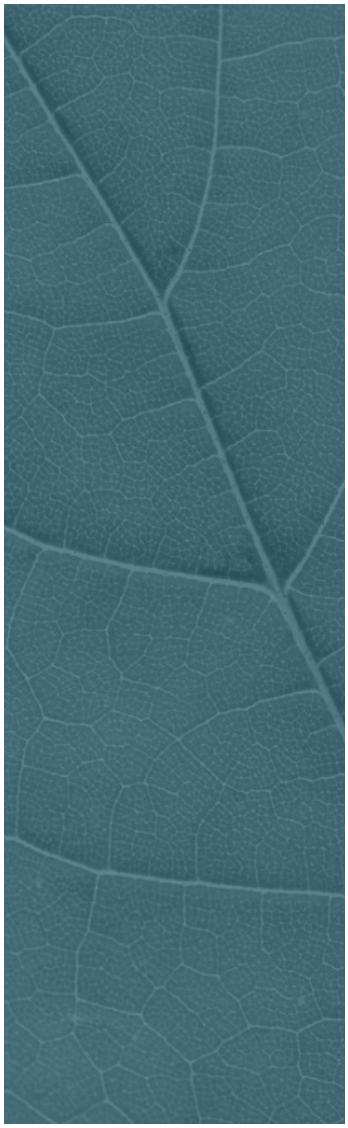

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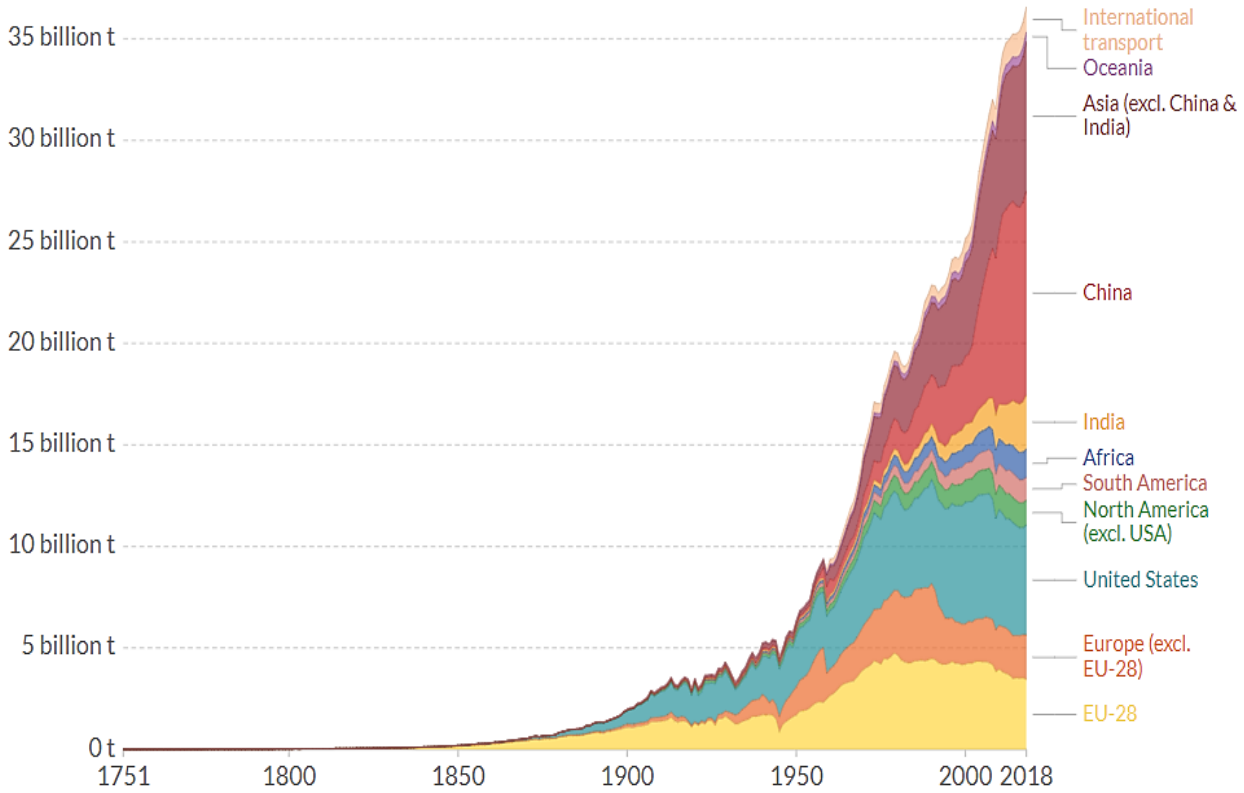
Introduction

The world has witnessed significant change since the dawn of the industrial revolution. Life expectancy has more than doubled; travel across the planet can happen in less than a day; loved ones can be reached via a video screen and vast quantities of information can be accessed at the touch of a button. But as our quality of life, and the science and technology that has facilitated this, has improved, so too has our impact on the earth's biosphere become more pronounced. Greenhouse gas (GHG) emissions in the earth's atmosphere – seven of which contribute to climate change, including carbon dioxide (CO_2), methane (CH_4,), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), hexafluoride (SF_6), and nitrogen trifluoride (NF_3) – have grown exponentially since the 1970s leading to a range of pernicious ecological, physical and health impacts.

For decades, scientists and activists have warned of the dire consequences awaiting the world if action to reduce GHG emissions is not taken. Catalysed by a growing number of extreme weather events alongside a strong wave of environmental activism, the majority of consumers, industries and governments have come to the consensus that action towards becoming environmentally sustainable must be taken.



Annual total CO_2 emissions, globally, from 1751 to 2018.
Carbon Dioxide Information Analysis Center (CDIAC); Global Carbon Project (GCP)

Sustainability to define businesses in the 21st century

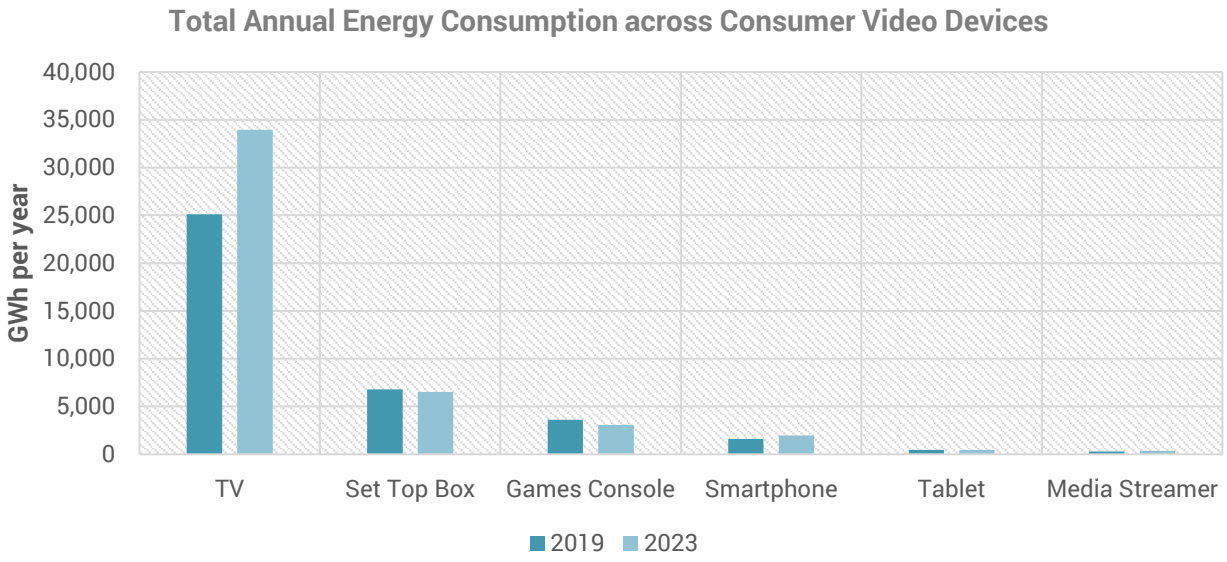
Across the business world, companies have looked at different methods of approaching their sustainability strategy, as well as improving energy efficiency. For larger firms, environmental sustainability has become a key pillar to their social corporate responsibility – although greenwashing has become commonplace in shaping strategy. Several technology and broadcasting giants have set ambitious targets: Apple, Amazon, and Sky have recently committed to go carbon neutral whilst Microsoft has committed to go carbon negative, all by 2030. Opportunities to become more energy efficient and reduce overheads are enticing, however, the issue at hand is far greater than improving public perception or saving money. Consumers and businesses alike must embrace sustainability and change practices to help protect the planet for current and future generations.

So where does this fit in for the television, film, broadcast, and distribution industries? Whilst there are low-hanging fruits that are discussed in this white paper, from carbon calculators to new technologies, the environmental challenges facing the planet require an end-to-end approach from every industry value chain. Sustainability must become an integral consideration from manufacturing and R&D to supply chain and logistics, forcing a change in strategy to the status quo: the assumed business model of the past has been predicated on productivity and greater profit margins, rather than on sustainability – a less tangible variable.

> *"The assumed business model of the past has been predicated on productivity and greater profit margins, rather than on sustainability – a less tangible variable"*

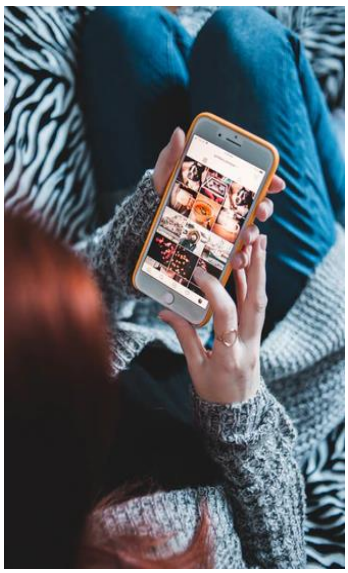
The video entertainment industry – which is accounted for by the production, delivery, and consumption of all video entertainment content, from feature films to console gaming – continues to see an uptick in its carbon footprint. This is a result of the digital revolution bringing technology and screens to the masses, and the increasing time consumers are spending on their devices, which has been subsequently catalysed by the COVID-19 pandemic.

At a time where the world becomes increasingly immersed in new video technologies, this white paper examines how the digital and green revolutions are converging and what the video entertainment industry is doing to address the challenges brought on by its expanding carbon footprint. Furthermore, it touches upon how the industry's landscape will be shaped by regulation and initiatives in the coming years, and how new technologies and concepts are helping businesses redefine their sustainability strategies.



Sustainability in the video entertainment industry

Environmental sustainability is only just beginning to be embraced by the video entertainment industry. Large broadcasters and producers, like the BBC in the United Kingdom and the Centre national du cinéma et de l'image animée (National Centre for Cinema and the Moving Image), have already considered an end-to-end approach in addressing their sustainability practices, driven by corporate social responsibility. However, while there is some understanding of what needs to be done in preparation and execution of more sustainable practices, processes, and solutions, there are several factors preventing the sector from fully embracing sustainability.



"One of the perennial misconceptions of green solutions is that businesses assume they are very expensive and so will impact their bottom line"

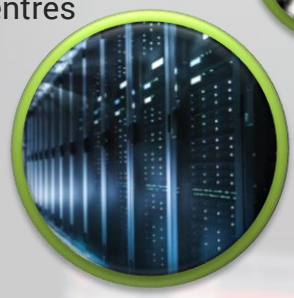
The first is the unknown costs associated with adopting more sustainable practices. One of the perennial misconceptions of green solutions is that businesses assume they are very expensive and so will impact their bottom line. The second factor is a lack of knowledge of the carbon footprint associated with video entertainment. For example, by 2022, video viewing will account for 82% of all internet traffic, according to CISCO's Visual Networking Index, with internet traffic accounting for well over 1% of global emissions. The third is the absence of government regulation or standards, across almost all jurisdictions, to monitor the carbon footprint and energy output across the video entertainment industry.

Global Video Entertainment
Facts & Figures (2019)

Estimated **379 TWh** total energy to run consumer electronics video devices*

Estimated **2,460 GWh** of energy to run data centres and CDN for streaming video

3% of global electricity used by data centres



Estimated **251 TWh** energy consumed by TVs in 2019*

30 million 8K TVs by 2023

213 million Gaming Consoles installed

912 million VoD Subscribers

1.8 billion TVs installed globally

167 million Netflix Subscribers

87 million Amazon Prime Subscribers

8.6 billion Cinema Admissions

$42bn Total gross Box Office revenue

* *Energy estimates based upon data from Futuresource's CE Market Tracking Service, multiplied by average consumption across consumer devices on the market today*

Initiatives across video entertainment

A concerted effort by government to implement initiatives and standards will be key for widespread sustainable change to happen. Providing incentives, through initiatives and grants, will be pivotal in catalysing how businesses change their attitudes towards sustainability. Whilst few legislations directly address the video entertainment industry currently, developed nations are on the cusp of seeing their regulatory landscape, with respect to environmental sustainability, change significantly in the coming decade.

The European Green Deal (EGD) – a set of policy initiatives by the European Commission, to be implemented in 2021 – has placed ambitious targets of reaching net-zero global warming emissions by 2050, with the video entertainment industry indirectly addressed through multiple targets. For example, one segment looks to address the high environmental footprint associated with data centres – key to the video entertainment space – stating that the ICT sector must undergo its own green transformation. Through the reuse of waste energy, the use of renewable energy sources and improved energy efficiency, the European Commission states that data centres can and should be climate neutral by 2030 and that initiatives will be put in place to achieve this.

> *"The European Commission states that that initiatives will be put in place to achieve climate-neutral, highly energy-efficient, and sustainable data centres by no later than 2030"*

Apart from the EGD, there have been several other EU initiatives that have sought to improve the video entertainment industry's sustainability efforts. For example, Horizon 2020 – a €77 billion research and innovation program focused on cleantech and sustainability – has looked at addressing data centres' energy consumption. This has included a 500 kW prototype data centre facility in Boden, Sweden, which uses renewable energy, a combination of free and evaporative cooling with no need for refrigerants, as well as low-carbon, locally sourced building materials. This government-sponsored scheme has a cost of €3 million.

Another case is the EU's Eco-design Directive, which launched Everywh2ere – a five-year project to create transportable, zero-emission replacements for diesel generators – to build eight plug-and-play gensets powered by hydrogen fuel cells to make servers more efficient.

European Green Deal Facts and Figures

- Objective to reach net-zero GHG emissions by 2050.
- Circular economy, including new waste and recycling laws, will be a main priority.
- Horizon Europe R&D and innovation program will have a proposed budget of €100bn from 2021 to 2027 with 35% of EU's research funding set aside for climate-friendly technologies.
- A goal of zero-pollution, whether in air, soil or water by 2050.

CineRegio has sought to standardise best practices uniformly across its membership, establishing a cross-regional sustainability certification scheme.

Across Europe, the majority of its Green members have official green protocols, charters, and/or certifications; in some jurisdictions, these are mandatory.

Across the film and production industry, local bodies and networks have looked to motivate firms to adopt more sustainable practices through initiatives and grants. The Green Screen Initiative – a partnership funded by EU's Interreg Europe consisting of regional development agencies, municipalities, and film commissions, including Film London, Ile-de-France Film Commission and Promalaga – aligns practices of partner regions and improves regional policies so that sustainable measures for producing films and television can be adopted across Europe. In France, the CNC is running an innovation scheme providing grants to companies that are demonstrating sustainable practices.

CineRegio – a network of 50 film funds across Europe – has also been a driving force behind sustainable practices across Europe's film industry, implementing a pan-European certification scheme for productions. Whilst practices and protocols vary between organisations, several CineRegio members have developed extensive guidelines, lists of sustainable suppliers, and carbon calculators for their respective regions.

Certifications: a guide for the consumer

Certifications continue to be an important tool in motivating moves towards sustainable products. Energy Star, developed by the U.S. Environmental Protection Agency (EPA), was established to reduce GHG emissions caused by inefficient use of energy. The scheme has been a successful way of educating the consumer on energy efficiency as well as motivating manufacturers to develop more energy efficient products.

Subsequently, the EU Energy Star programme has been established, as well as Energy Star programs in Canada, Japan, and Taiwan with computers, servers, and home electronics amongst the categories being measured. Despite the positive progress made by the initiative, future iterations could be undermined by a lack of funding from the Trump administration.

Certification schemes, like Energy Star, can only go so far in addressing sustainability across video entertainment, as it only tackles the energy efficiency of a product or device. A complete measurement of sustainability needs an approach where a company's total activity, both direct and indirect, are considered so that their end-to-end carbon footprint can be fully assessed.

Facts and Figures

- Across all SVoD platforms, there are 951 million subscribers, globally
- Amazon Prime has 10% market share
- Netflix' share of the market is 18%

The growth in video content consumption

The video and TV industry has continued to witness significant growth thanks to technological advancement in over the top (OTT) content delivery. Video on demand (VoD) services have been integral to this growth by stimulating a revolution in content consumption by providing audiences a platform to watch what they want, when they want. The race to win audience share has helped catalyse a production boom in high-end episodic TV as service providers bolster their catalogue of content by buying and commissioning exclusives and "originals".

"In the USA, 86% of SVoD households are subscribed to at least two services"

The burgeoning subscription video on demand (SVoD) and ad-supported video on demand (AVoD) markets have created a wealth of consumer choice in premium video entertainment. The abundance of services available is illustrated by the number of high-profile launches in the past year, including Disney+, Apple TV+, HBO Max, and Peacock. As audiences migrate to VoD platforms, a trend of "service stacking" has emerged as many consumers perceive their respective content libraries to be complementary.

Video streaming: striking the right, sustainable balance

A satisfying video streaming experience relies on striking a balance between image quality, latency, and scalability. The required bandwidth to support all three aspects is driven upwards by new technical innovations, such as higher resolutions, increased frame rates, and dynamic range, resulting in the use of higher bitrate video formats for the same duration of content. To counteract this and achieve a reduction in bandwidth, without sacrificing latency, scalability, or quality either an improved transport protocol and/or more efficient video compression specification must be used.

"By 2022, video viewing will account for 82% of all internet traffic"

CISCO Visual Network Index

In July 2020, THEO technologies and Synamedia partnered to launch the HESP Alliance to encourage adoption of HESP (High Efficiency Streaming Protocol). It is claimed that this can cut bandwidth costs by 20% versus existing solutions such as DASH CMAF-CTE. The first HESP products are slated for Q4 2020 and 3rd party offerings are set to follow in 2021. Although the change in protocol will only deliver a small quantity of carbon mitigation on a per user basis, Interreg's Green Screen assessment advocates for the protocol's adoption

because the large overall user base of video streamers will together contribute to a significant cut in emissions by CDNs converting to HESP.

An evolutionary moment in video encoding

The industry is currently poised for the introduction of a variety of new video codecs. The Moving Picture Experts Group (MPEG) standards body will release three new codecs in 2020: Versatile Video Coding (VVC), Essential Video Coding and Low Complexity Enhancement Video Coding (LCEVC). The formation of the Alliance for Open Media with the objective of delivering an open source competitor to HEVC for video streaming has also given rise to the creation of a rival codec AV1.

The practical implementation and adoption of new codecs will be determined by their technical specifications and the return on investment that they are able to deliver. In setting sustainability criteria for selecting a new codec, this should evaluate its capability to create operation efficiencies that will reduce Scope 2 emissions, although without end-to-end measurement this is challenging to evaluate. Re-encoding an existing content library into a more efficient codec enables content owners to spend less per item of content on both storage and distribution. As the measurement of carbon emissions becomes more pertinent in the video content supply chain, demonstrating the extent to which power consumption can be reduced through the deployment of a new codec may aid in accelerating adoption.

Standard	Organisation	Release	Main contributors	Silicon	Volume
AV1	AOM	Jul 2018	Amazon, Cisco, Google, Intel, Microsoft, Mozilla, Netflix	Sep 2019	2021
EVC	ISO	Apr 2020	Divideon, Huawei, Qualcomm, Samsung, Tencent	2022	2023
VVC	ITU/ISO	Jul 2020	Broadcom, Bytedance, Ericsson, HHI, Huawei, InterDigital, MediaTek, Nokia, Qualcomm, Samsung, Tencent	2022	2023
LCEVC	ISO	Oct 2020	V-Nova	May 2020	2021

The same principle applies for the development of both video delivery protocols and codecs in the future. Any that can aid end-to-end optimisation of the content delivery chain to focus processing at stages that use more power efficient software, or hardware, than others will contribute to a net decrease in the overall Scope 2 emissions created over the course of the video content's journey from the provider to the consumer.

Sustainability through the user interface

User interface (UI) design provides an opportunity for audiences to make more sustainable decisions. In the same way that option boxes are used to counteract video latency or buffering by asking if the user wants to reduce their video resolution, a platform could also inform a viewer of how they can reduce their energy consumption by notifying them of options when selecting content. Offering consumers a choice between UHD and "Eco" video streaming might become commonplace, but there's an open question on whether they will pay more for the "greener" streaming alterative.

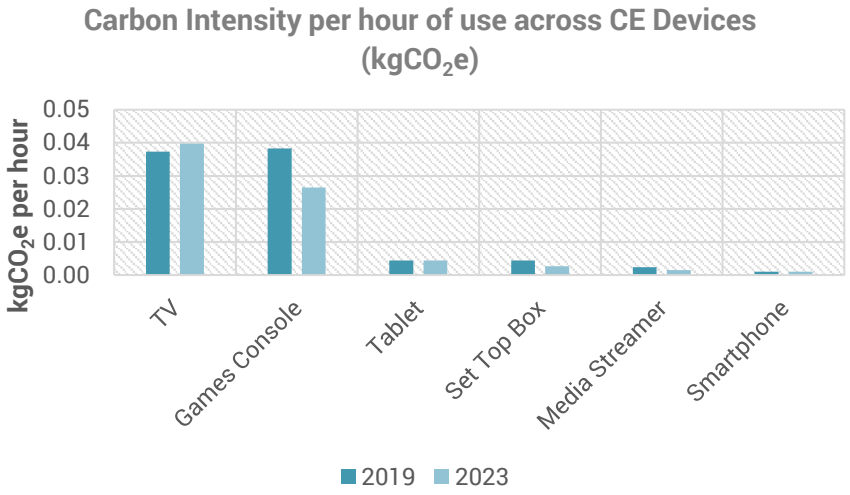
In a shared household, UI changes can be used to counteract the fragmentation of viewership by encouraging more shared viewing experiences, avoiding individual tendency towards personalised viewing on separate devices, Services with user profiles could notify each user if they are watching the same content as others in the same household. In a connected smart home environment, it could even suggest the optimal viewing device for the combined audience.

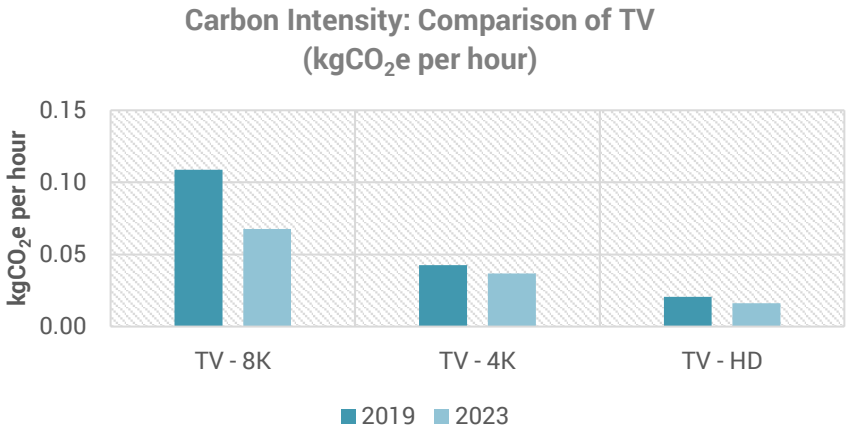
The Consumer Video Entertainment Carbon Footprint

- Watching TV for an hour generates 37gCO_2e
- Watching a favourite TV show on a TV + STB combination accounts for 43gCO_2e per hour
- On average, a 4K TV creates double the emissions of an HD TV
- Use of a media streaming stick can contribute 2gCO_2e per hour
- Games consoles produce 38gCO_2e per hour
- The Xbox Series X is over twice as efficient as an Xbox One

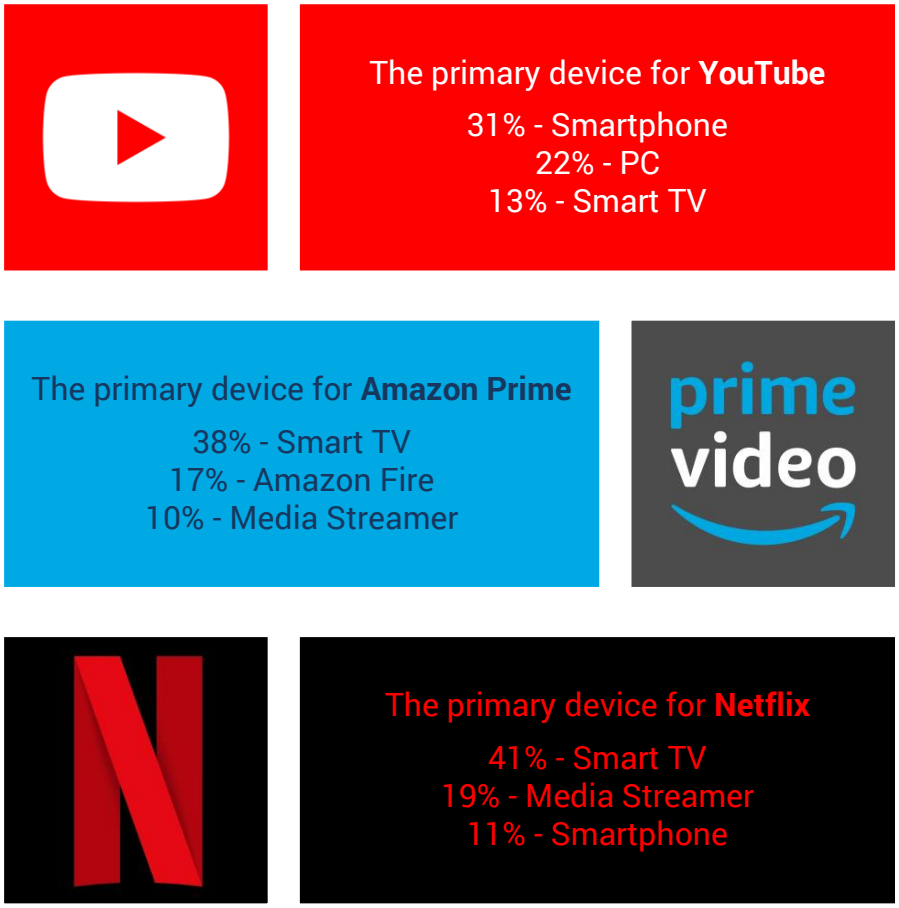
Consumer electronics and consumer choices

At present, awareness surrounding the environmental impact of each video consumption device is minimal. For example, there is little understanding of power consumption across different TVs. An 8K TV uses more than twice as much electricity than a 4K TV, which shows in energy bills; however, users are unaware that this accounts for 108gCO_2e per hour of emissions, 2.6 times higher than the equivalent 4K set. To put this into context, for the expected 30 million 8K TVs that will be installed by 2023, energy consumption for video streaming will be 50% higher than 343 million tablets used worldwide. As consumer engagement with sustainability increases, these choices will attract greater scrutiny.





There is growing responsibility for manufacturers to educate their customers about their devices and how to use them in a responsible manner. Given the success of EPA's Energy Star scheme, advocating for the introduction of similar initiatives in other regions will help pressure vendors whilst also raising consumer awareness. The environmental cost of consuming video content is not only determined by a service provider's infrastructure but also by the consumers own viewing habits. Device ownership, utilisation, power consumption and replacement cycles are all important variables in accessing how sustainable a consumer's own preferences are.



Preferred device for consuming streaming video services
Futuresource Consumer Research: USA and EU5, December 2019

PlayStation

2020 marks an evolutionary moment for the video game market as Microsoft and Sony launch next-generation consoles: Xbox Series X and PlayStation 5.

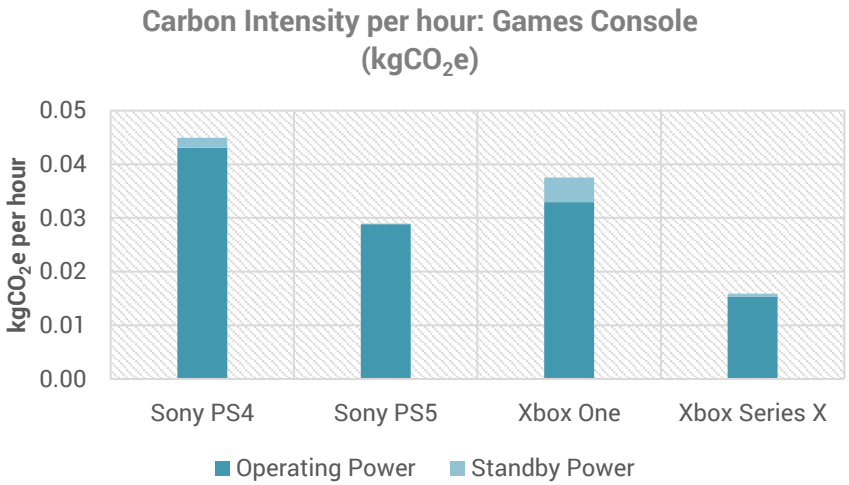
These two new flagship models will stimulate another cycle of hardware demand for the next three to four years.

Increasing gaming whilst reducing carbon emissions

As a mobile-first generation emerges, an increasing portion of consumers' free time is being devoted to playing video games. As game time increases, so too has the energy efficiency of games consoles. PlayStation 5 will achieve a reduction in PlayStation's total carbon footprint from 45gCO_2e per hour in 2019 to 36gCO_2e per hour in 2023, per device. Although PlayStation can expect its total install base to grow by 20% from 2019 to 2023, overall power usage of devices will only increase by around 4% in this time frame.

Moreover, the Xbox Series X, set to be released in late 2020, will also directly contribute to the reduction in Xbox's total footprint given the new console uses less than half of the power of Xbox One. Emissions will reduce from 38gCO_2e per hour in 2019 to 26gCO_2e per hour in 2023 per device; even though the installed base of Xbox consoles will grow by 21%, power consumption of Xbox devices overall will reduce by 16%.

Adjacent to the next phase of the console war, mobile gaming is fuelling broader engagement with video games. The prevalence of mobile devices aids accessibility to content for users in developing regions. Players are often enticed by free-to-play content but can be converted to regular spenders through downloadable content (DLC) and in-game microtransactions.



Digital downloads accounted for 38% of video game volumes in 2019 across both console and handheld devices and are forecast to continue to cannibalise the demand for games delivered via physical media. New releases and DLC expansions can create a spike in downloads and a resultant surge in overall network traffic. While digital delivery offers convenience to the consumer in accessing titles, gamers will be frustrated by lengthy download times. Activision Blizzard's first-person shooter Call of Duty: Modern Warfare recently came under fire for issuing its Season 2 DLC with a file size that came close to that of the full game. Smart management by consoles to schedule downloads overnight during network downtime could alleviate some of the pressure placed on the infrastructure but would rely on communication between the internet provider, digital marketplace, and the end-user's device.

Is streaming the future of video games?

Making games available to stream will free players from the burden of having to use device storage capacity on digital downloads and represent the advent of a totally new distribution model. A swing to streaming would place greater pressure on CDNs and data centres to support low latency game play but should require less compute resources from the edge-device itself.

At present, the streaming market is relatively immature. Google Stadia was launched in November 2019 and the service has faced issues in cultivating a dedicated userbase. As more developed streaming services emerge for gamers, a wholesale migration could contribute to a decrease in the overall peak load on broadband networks by eliminating concentrations of data heavy downloads when new games and DLC are released.

Sustainable manufacturing

Manufacturers that can demonstrate sustainable practices in their manufacturing and supply chain carry favour with environmentally conscious consumers. Several global leaders in the consumer electronics sector including Logitech, Microsoft, Panasonic, Phillips, Sony, have joined The Climate Group and CDP's initiative RE100 HP which aims to encourage the use of renewable energy to accelerating progress towards eliminating carbon grids globally by 2050 at the latest.

Recycling has become essential in managing the material waste created by consumer electronics. Samsung operates a waste reclaim scheme in 54 countries through which the manufacturer can collect steel, aluminium, copper, and plastics for use in new devices. Apple has actively incentivised trade in devices and sells refurbished ones to facilitate multiple lifespans per product. Resellers, such as CExchange, have been able to cultivate a thriving secondary market for devices whilst waste diversion is also an important strategy to limit the use of landfill. Dell, for instance, has incorporated reclaiming ocean-bound plastics into their supply chain for packaging. Its production of moulded product trays can now avoid the use of any virgin materials by combining a mix of 25% ocean-bound plastics with 75% recycled polyethylene terephthalate (PET).

Manufacturers are also waking up to an influencer marketing world, where consumers are leading the conversation on sustainability, which is swaying buying habits. Alongside this, a greater focus on sustainability in the education system is emerging, including the addition of the UN's Sustainable Development Goals (SDGs) to curriculums. Manufacturers and retailers alike must now set ambitious sustainability targets to prepare for a new generation of consumers that do not view sustainability as a goal but as an expectation.

Measuring sustainability across video entertainment

Measuring sustainability represents a challenge to the video entertainment industry given how multifaceted and intangible a variable it is. This measuring process becomes even more difficult given the multitude of indirect and direct channels that contribute to a company's carbon footprint.

The Albert Production Carbon Calculator accounts for total GHG emissions as a direct result of making a programme. The user is given the total CO_2 emitted over the course of production, CO_2 emitted per £100k of budget and CO_2 per production hour. The carbon calculator accounts for carbon footprint of:

- Production office
- Studio
- Travel
- Accommodation locations,
- Materials used
- Post-production

Across the video entertainment supply chain, there is no specific code of conduct or ISO standard detailing how energy consumption or carbon emissions should be reported. Despite this, there is an awareness that content creation, consumption and production consume significant resources, and that the industry must become more accountable.

In the absence of standardised measurement cross industry, several bodies across video and film entertainment have looked at ways to measure their industry's carbon footprint directly. For example, the BAFTA Albert Consortium, from the UK, created a carbon calculator, called Albert, which encourages production companies to assess their emissions. The Albert calculator allows production houses to quickly understand their environmental impact. If a company is producing for UK channels – BBC, ITV, Channel 4, Sky – or Netflix in the UK, they must now calculate their carbon footprint with Albert. The carbon calculation is then tied to a certification, which rewards and incentivises firms to be more sustainable.

Throughout Europe, the development of carbon calculators and other scoring systems have been pursued by similar film and production bodies, such as Ecoprod's Carbon'Clap and Screen Brussels. There is a consensus that due to the international nature of many productions, a standardised carbon calculator is now needed to drive greater accountability and comparison between regions, which CineRegio has been advocating for in Europe's film industry. For example, the Flanders Audiovisual Fund, a Green member of CineRegio, is investigating ways of improving its Flemish CO_2 calculator, which can quantify logistical choices to show the relative impact of staff and goods transportation when selecting between two different filming locations.

There are three main emission types to consider in sustainable ecosystems:

1. **Scope 1 – Direct greenhouse gas (GHG) emissions:** This covers direct emissions from company operations (e.g. diesel generator emissions, company vehicle emissions, etc)
2. **Scope 2 – Indirect greenhouse gas emissions:** This covers electricity consumed, office heating, renewable energy purchase agreements, renewable energy credits (RECs)
3. **Scope 3 – Indirect emissions coming from business operations:** Covers anything from corporate travel, or energy consumed by products designed by the company that are used by others, with focus on upstream and downstream activities. Upstream includes emission factors that occur when a product is sold by the producer. Downstream occurs once the product is sold and includes storage and end-of-life activities such as shipping and recycling

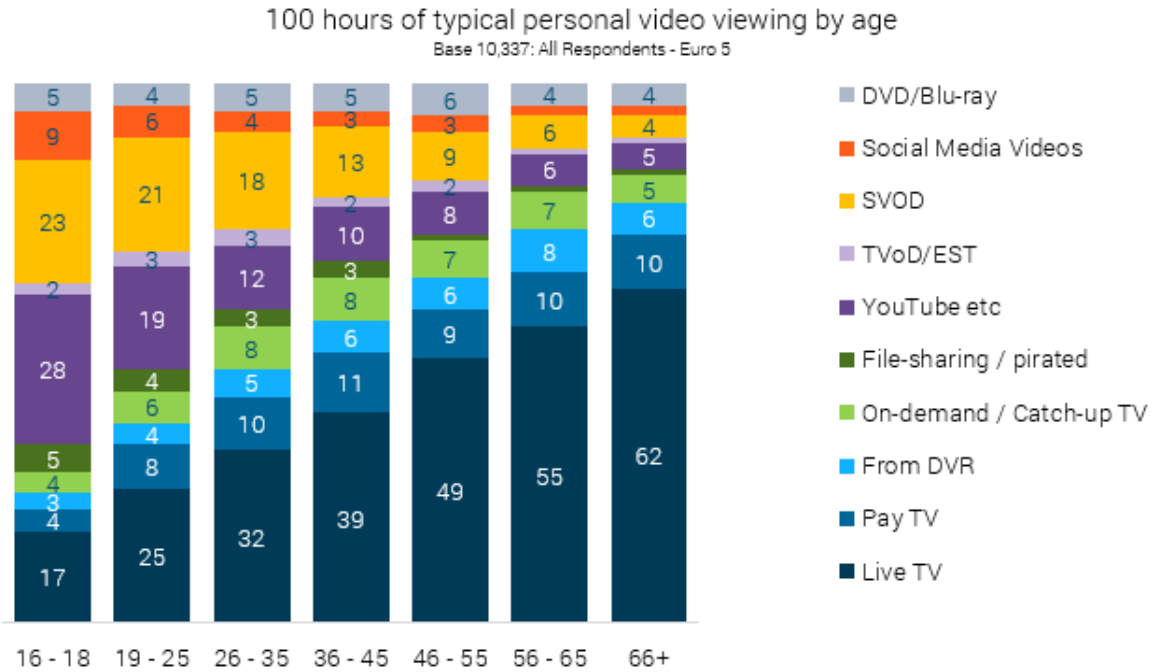
Changes in broadcast business models

The issue of sustainability is pertinent to broadcasters, particularly as the industry faces its greatest technical revolution since analogue to digital – the move from SDI to IP system architectures. This transition manifests itself at an infrastructure level as mission critical workflows are migrated from proprietary SDI hardware to IP networks.

This period of investment in new infrastructure provides an opportunity for the inclusion of sustainability objectives. A greater awareness of the responsibility for companies to operate sustainably, especially by broadcasters in the EU, is contributing to a rising expectation for new build facilities to target sustainability objectives, with the aim of futureproofing investment for years to come. However, industry feedback also agrees that it is easier to get it right when working with a blank slate. Improving incumbent facilities filled with older, less efficient, hardware can be more challenging.

The availability of cash for upgrading existing facilities is not always easy to come by, especially as broadcasters feel the squeeze as budgets remain tight due to rival digital platforms increasingly eating into their share of revenues from advertising spend. Audiences are also turning to an ever-growing pool of user generated content that can range from simple home video clips shared on Instagram and TikTok to more polished content made by aspirational creators for YouTube or Twitch.

The current commercial pressures faced by broadcasters make it difficult for organisations to proactively invest in technology to improve their sustainability. Among public service broadcasters. it is a slightly different story: Money can be ringfenced for sustainable initiatives as part of the organisations' contractual obligations to serve the public interest. The current situation largely gives rise to an environment where cost savings are achieved



through implementing greater efficiency. This is creating a demand for technologies that can speed up production timelines, reduce crew needed to produce quality content, improve monetisation of content, or reduce the number of facilities (and overheads) through consolidation. Many of the solutions to these problems improve sustainability of operations as a by-product.

- Smart indexing and AI metadata tagging of library assets and stock footage aids rapid retrieval. Footage can be repurposed for new content and even prevent the need for new shoots to take place.
- The use of the remote integration model for production and other decentralised workflows enabled by the deployment of IP networks can increase the utilisation rates of both equipment and crew. This helps mitigate Scope 3 emissions by reducing the amount of equipment and crew that are required to travel to the venue or location.
- The use of Interoperable Master Format (IMF) can help limit the amount of processing required to create copies of content masters.

If the broadcast industry were to pivot towards a leaner production and distribution model this would create significant progress in the interest of sustainability.

Smart monitoring of resource utilisation and the application of AI/ML to improve decision making can result in higher utilisation of equipment and assets as well as lead to less waste and storage throughout video content production and distribution.

The alignment of sustainable practice with creating greater operational efficiency will be a vital step forward for decision makers as ultimately the survival of the broadcast industry relies on sustainability being made an objective from the outset in all activities, both from a commercial and an environmental perspective.

Linear or on-demand: which is more sustainable?

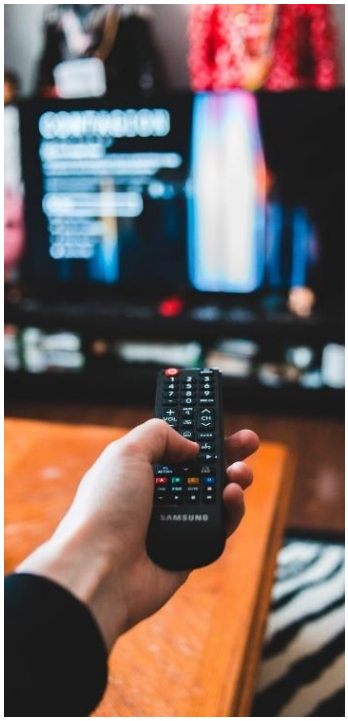
In the past few years, terrestrial TV has had to contend with the emergence, and now mainstream usage, of OTT video. The proliferation of devices has created more opportunities for consumer video over the past decade, especially as both broadband and mobile data speeds have increased, enabling more convenient consumption.

The distribution of video content is fundamentally different when broadcast TV and OTT video are directly compared. Broadcast, by definition, operates on a model of one to many, whilst OTT can offer a more personalised service, serving up bespoke content to every individual on demand as a non-linear experience. Inevitably the inherent differences between their respective infrastructures gives rise to crucial differences when viewed through the lens of sustainability.

In the UK, the BBC undertook a comparison of the carbon cost of delivery of digital terrestrial TV (DTT) and VoD and concluded that DTT has a smaller carbon footprint per viewer-hour than VoD for average sized audiences. The

fundamental difference here is that terrestrial broadcast has a fixed energy cost associated to its distribution, however, the energy cost of IP distribution used for VoD scales relative to audience size as the network must add capacity. Broadcasters worldwide conclude that channels with large audiences are better delivered by terrestrial transmission, while channels with niche audiences are suited to IP. Standards, including DVB-I, allow broadcasters to add IP-based programming to the EPG and select the appropriate transmission mechanism, even on a per-programme basis. Consumers needn't know which is being used, as this switch is seamless.

"Digital terrestrial TV has a smaller carbon footprint per viewer-hour than VoD for average sized audiences"



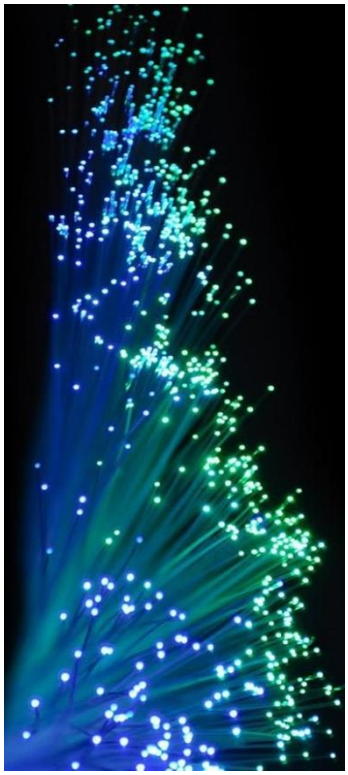
One of the crucial aspects of IP delivery that drives up Scope 2 emissions is the chain of connected devices in the consumer's home that are necessary to deliver content to their screens. Typical combinations range from a Smart TV on a wireless connection from the home router to smartphones on a mobile network. Secondly the number of viewers per screen has a direct correlation on the sustainability of the viewing session, since the environmental impact diminishes overall when serving to a family rather than individual viewers.

As the overall trajectory of the video entertainment industry shifts increasingly towards IP delivery, service providers will invest in the growth of a distribution model with the potential for a far greater carbon footprint than its predecessor. If the industry is to make VoD sustainable, ambitious targets must be set to ensure that the industry actively develops and deploys measures to mitigate and offset the carbon emitted by OTT video delivery.

The rise to dominance of IPTV-delivered OTT is not without other advantages. By leveraging a broader ecosystem of enterprise IT equipment and services, moving away from proprietary broadcast hardware, the video supply chain will benefit from advancements in sustainability that are achieved by the IT sector. For instance, within the EU, all broadcasters using cloud workflows and virtualised resources stand to benefit from the reduction in Scope 2 emissions. Commoditised off the shelf (CoTS) IT hardware also attracts greater scrutiny for lifecycle assessment and is a target for the development of new power consumption standards. This enables content providers to reap the rewards of advancements made by CDN and data centre providers as they invest in making their infrastructure more sustainable.

Is video sustainable over broadband?

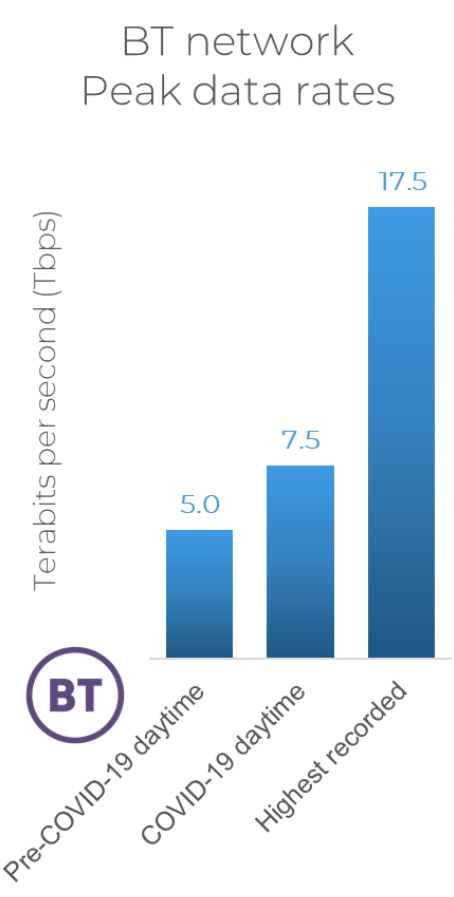
There has long been a debate over whether broadband infrastructure is capable of sustaining television services streamed over the internet. Broadcast remains favourable for the transmission of live events, given the wide audience reach, however the arguments for broadband not being a feasible alternative, citing CDN costs or network bandwidth restrictions, have



largely evaporated in recent years. Broadcasters worldwide have IP-based catchup services; and major streaming providers, including Amazon, Apple, Netflix, YouTube, Disney, Roku, Hulu and others illustrate that commercial video services are entirely feasible and profitable over broadband.

Superfast broadband – defined as that offering speeds above 30 Mbps – is sufficient for reliable video streaming. Leading streaming service providers quote a minimum of 5 Mbps for HD, and between 15 Mbps to 25 Mbps for UHD (4K) video streaming. In June 2020, global fixed broadband download speeds averaged 78 Mbps, up 32% from 59 Mbps one year earlier, with 90 countries today posting headline average speeds of over 30 Mbps. Average monthly broadband data usage is increasing, supported in part by uncapped data plans alongside migration to faster services. Median broadband data usage surpassed 344 gigabytes per month in Q4 2019, and this is expected to exceed 425 gigabytes per month by the end of 2020.

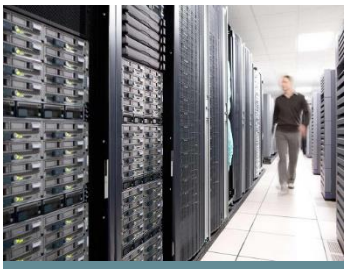
The COVID-19 pandemic illustrated just how robust and resilient global broadband networks are. This is expected to accelerate innovation in IP-based television services. Across Europe, there was only a 1% decline overall in average downloads speeds during the onset of lockdown, accompanied by a 3.6% decline in mobile speeds (for comparison).



Major streaming providers, including Amazon Prime, Netflix, Apple TV+ and YouTube all reduced their video bitrates to relieve the pressure upon ISPs, yet most operators reported their networks were running well under peak capacity.

Broadband networks are designed to handle increasing load and usually see traffic grow by up to 40% over a 12-month period; during the pandemic, this happened in just one week. In fact, COVID-19 simply shifted peak usage to earlier in the day. UK operator, BT, reported that traffic on their network backbone increased by 50% to 7.5 Tbps during COVID-19 lockdown, yet the highest ever recorded usage was 17.5 Tbps, driven by a tier-1 video game update happening simultaneously with streaming of a major football match.

Our study finds that broadband in developed regions has plenty of headroom for IP-based video, and that this will increase as capacity in both fixed-line and mobile networks is being continually expanded.



PUE determines the energy efficiency of a data centre, expressed as a ratio of the total power entering the facility divided by the power consumed by IT infrastructure.

A PUE of 1.0 represents ideal conditions.

Sustainability is essential in data centres

Given the expansion in online video over the last decade, data centre energy efficiency and sustainability have become mandatory considerations for streaming service providers. Firms such as Amazon, Facebook, Google, and Microsoft run their data centre operations very efficiently and have committed to a transition to 100% renewable energy.

"Data centre power amounts to 416 Terawatts globally, equivalent to around 3% of all electricity generated annually"

Power usage effectiveness: a key metric for sustainability

Many data centres use almost as much energy for non-computing functions, such as for cooling and power conversion, as they do to run the servers themselves. According to the Uptime Institute's 2019 Data Centre Survey, the global average power usage effectiveness (PUE) of the largest data centres is 1.67. To counter both rising electricity costs and concerns about CO_2 emissions, hyperscale cloud companies with larger colocation facilities are today achieving annual PUE figures of between 1.1 and 1.4.

Efforts to improve the energy efficiency of the mechanical and electrical infrastructure of data centres are now producing only marginal improvements. So, the focus must move towards IT. The most-implemented practices for energy reduction are those that do not require substantial investment but do require process, discipline, or relatively minor and incremental investments.

"40% of servers are over five years old; these account for 66% of energy use but contribute only 7% of compute capacity"

Uptime Institute

In the video streaming sphere, the answer to improved sustainability comes from increased server utilisation and the use of virtualisation for multi-tenancy. At the workload level, the rise of the cloud and virtualisation has helped boost server utilisation levels from around 5% at the beginning of the decade to around 65% more recently. AWS report that companies using their data centres typically reduce carbon emissions by up to 88%, with organisations provisioning fewer than a quarter of the servers than they would require locally, using up to 84% less energy overall.

Artificial intelligence and machine learning are also part of the solution: Google's acquisition of DeepMind led to the development of a computer model that reduced energy used for cooling Google data centres by 40%.

How much energy do streaming services use?

Due to such enhancements in server architecture and network switch efficiency, electricity usage in video downloads is decreasing and emissions intensity is declining faster because data centre providers are rapidly moving to zero emission sources. Arguably, no industry has done more to consistently re-engineer its core architecture for measurably reduced power consumption than the data centre industry.

According to research by Dr. Jonathan Koomey at Stanford University, data centres today consume as little as 0.015 kWh per gigabyte in the transmission of data through the internet to a user. This is the average for all classes of data-driven applications including, but not limited to, streaming video.

Netflix video data centre
Image credit: Netflix

For Netflix, one hour of 4K video consumes 7 gigabytes of data; and an hour of HD uses 3 gigabytes. Therefore, energy usage at the data centre is 0.105 kWh for an hour of 4K video, and as little as 0.045 kWh for the equivalent HD stream. By this metric, HD consumes only 42% of the energy required for 4K UHD.

> *"At the data centre, HD video consumes only 42% of the energy required to stream 4K UHD"*

The importance of content delivery networks

The major video streaming service platforms use content delivery networks (CDNs) to optimise bandwidth utilisation and reduce latencies across broadband networks. High integrity is key to the video service proposition, so these companies install video servers and storage arrays at strategic points in the network, ensuring that the content is cached locally to subscribers.

Sustainability in video CDN is centred squarely on server workloads, CPU utilisation and optimised network usage. Storage servers are populated with content overnight when network traffic loading and energy costs are lower; bulk transfers are minimised by peer-to-peer networking, ensuring the content is only transferred once across major network links, then replicated locally.

Appliances that once handled the task of load balancing have been replaced by software-based microservices that distribute workloads much more efficiently, and at a very granular level.

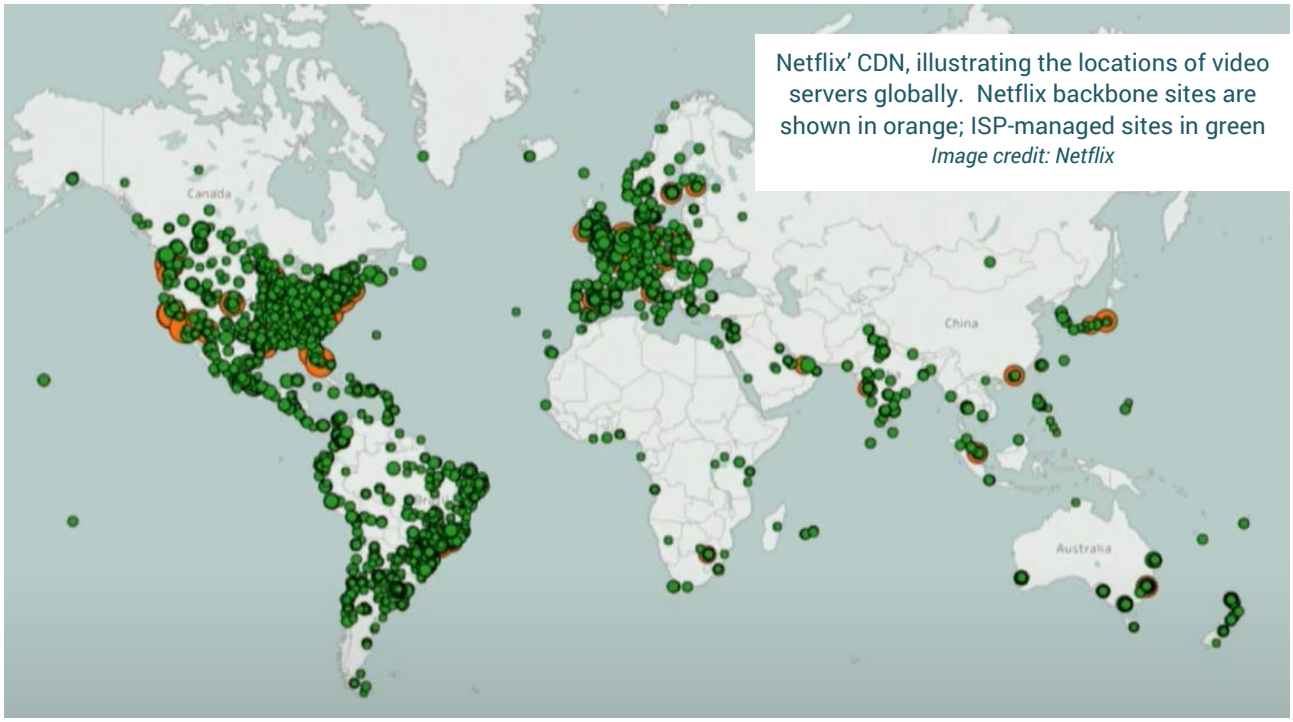
By way of examples, Hulu employ Amazon Web Services' (AWS) CloudFront CDN to deliver their catalogue of over 75,000 video-on-demand programmes and a live TV service that ingests 1,000 streams daily, delivering to 32 million subscribers. They relocated their video data storage facility to a data centre in Las Vegas running on 100% renewable energy, eliminating 265,000 tCO_2e of emissions annually.

> *"Hulu's move to 100% renewable energy eliminates 265,000 tCO_2e annually"*

Netflix also run most of their business logic in AWS, but through it's Open Connect platform, the company maintains its own video CDN by supplying server hardware free of charge to major ISPs; they also monitor and manage these servers remotely to ensure optimum operation.

Two kinds of servers are provisioned: 1), storage server appliances holding portions of the Netflix video catalogue in bulk on hard drives, which are relatively slow; and 2), flash-based "offload" servers that have solid state drives with significantly higher throughput, serving the most popular content to subscribers.

There are over 10,000 servers in the Netflix CDN deployed across thousands of sites globally. The majority of sites are handled by ISPs with servers supplied by Netflix, whereas in the network backbone Netflix directly controls



Netflix' CDN, illustrating the locations of video servers globally. Netflix backbone sites are shown in orange; ISP-managed sites in green
Image credit: Netflix

and manages each site. To reduce environmental impact, Netflix invests heavily in carbon offsetting programmes and in the purchase of renewable energy certificates (RECs) to match 100% of the direct power consumed by data centres it controls.

In terms of the hardware, storage appliances typically occupy 2U of rack space, have a peak power draw of 500 watts, and provide 288 terabytes of storage capacity for the Netflix content catalogue; these also store the content metadata, including programme synopsis, the box art, screenshots and movie trailers. The offload servers are smaller at only 1U, drawing peak power of 300 watts, each with 14 terabytes of raw storage; these deliver content to the network at up to 35 Gbps, serving around 5,000 HD streams concurrently.

NETFLIX	2018	2019	% increase
Direct energy usage	51 GWh	94 GWh	+84.3%
Indirect energy usage	194 GWh	357 GWh	+84.0%
Total energy usage	**245 GWh**	**451 GWh**	**+84.1%**
Subscribers	139.3m	167.1m	+20.0%
Energy per subscriber	1.76 kWh	2.70 kWh	+53.5%

It's a massive operation resulting in Netflix directly using 94 GWh of energy in its own offices, studios and the telecommunications facilities that are part of its content delivery network, plus a further indirect energy use of 357 GWh, which covers Netflix servers co-located at internet service providers; a total of 451 GWh in 2019. This represents an increase of 84% from the 245 GWh Netflix said it used in 2018.

> *"Netflix used 451 GWh of energy in 2019, sufficient to power 115,000 average European homes for a year"*

The company's energy consumption far outpaced its user growth: in 2019, Netflix's worldwide paid subscriber base grew 20%, to 167.1 million. The increase in energy equates to a 54% rise per subscriber. This is partly due to a change in content encoding, and it's likely that the 2019 catalogue of popular films were delivered in the higher HD 1080 resolution. Equally, it's feasible that Netflix re-encoded their content catalogues to HEVC, and the "savings" allowed them to present subscribers with a 1080 HD resolution service by default.

The Netflix example illustrates just how large the impact of video streaming is on the environment; indeed, other major platform providers will be similar in scale. This is not to call out Netflix as a bad actor in the industry. Moreover, it is only through Netflix' transparency of reporting that we can present insights into the typical energy usage of the video streaming industry.

Opportunity for new, sustainable technologies in film

- The development of more efficient codecs to reduce file transfer and storage demands
- Deployment of remote production workflows to reduce travel and transport whilst also increasing equipment utilisation
- Optimisation of data centre and compute resources for VFX and post-production rendering
- Using augmented and virtual reality technologies for pre-production, pre-visualisation and collaboration as well as reducing location travel
- Reducing on-set energy use by replacing tungsten lighting fixtures with LED alternatives

How the film industry is prioritising sustainability

As the pinnacle of high-end video content creation, the film industry is easily perceived to be a resource intensive endeavour that creates a high level of waste. Senior decision makers showcase an awareness of this reputation and a pressing need to improve. The inherent difficulty is making a comprehensive assessment of the supply chain due to the vast range of services that are used. Production is heavily reliant on contractual services. However, production companies that commit to employing sustainable practices have an opportunity to both educate and drive demand for reform across a broader ecosystem of suppliers, spanning several sectors, from catering and hospitality, to facilities and transport.

Transport, catering, waste, and power all contribute heavily to the carbon footprint of a film, although strategic changes to working practices can scale this back. Several industry leaders from the film sector have advocated that even an extra week of planning in pre-production can allow heads of department to take meaningful decisions that improve sustainability over the course of an entire production. In many cases, the costs saved through the operational efficiencies created comfortably offset or even exceed the price of employing a sustainability officer.

National film funds can play an active role in encouraging greater incorporation of sustainability into the filmmaking process by incentivising productions that follow green principles, but also encouraging sustainability to be factored into the narrative and editorial decisions. Research participants from the film sector agreed that the industry has a role to play in raising consumer awareness and normalising sustainable behaviours by representing them on screen and telling empowering stories about climate change that mobilise audiences into taking action.

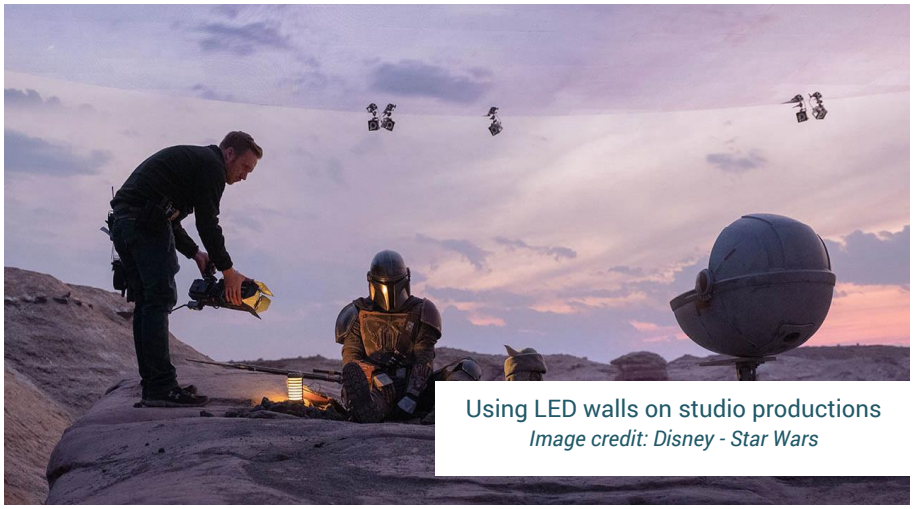
Making video production sustainable

Like TV, the film industry holds a powerful influence over popular culture and when mobilised to tell impactful stories can help change perceptions and educate audiences. Issue-led features and documentaries with a sustainability focus can create positive awareness and bolster a studio or production company's reputation for championing sustainability but may not be representative of their own operational commitments. Improvements must be made proactively across pre-production, production, and post-production.

To be most effective, sustainable initiatives must be an objective from the outset of a project and pre-production is a vital opportunity to plan for tools and methods that will pay off later in production. Technology can be used at this stage to aid collaboration and reduce travel by using video conferencing for meetings, whilst VR opens new possibilities for location scouting and previsualisation.

Location-based production can be resource intensive as the unit bases used to support crew, craft and equipment are typically only temporary installations. Cultivating a green infrastructure that productions can tap into is vital. Recent technological advancements in virtual production are making it easier to convincingly simulate locations from the studio, removing the need for travel

altogether. The convergence of motion picture and video game technology has made real-time manipulation of 3D virtual assets a possibility on set. Jon Favreau's *The Mandalorian* was able to shoot a diverse range of sci-fi locations from a unique studio stage – "the volume" – by using mixed reality. The production team used camera tracking data to map virtual locations that were visualised with Epic Games' Unreal Engine onto a panoramic LED screen backdrop, removing the need for the use of green screens and associated post-production processes.



Using LED walls on studio productions
Image credit: Disney - Star Wars

Where the physical construction of sets is still required, a circular economy has arisen to ensure that material wastage is minimised. Interreg's Greenscreen initiative outlines how to further enhance the lifespan of sets by using reusable wood moulds in their construction.

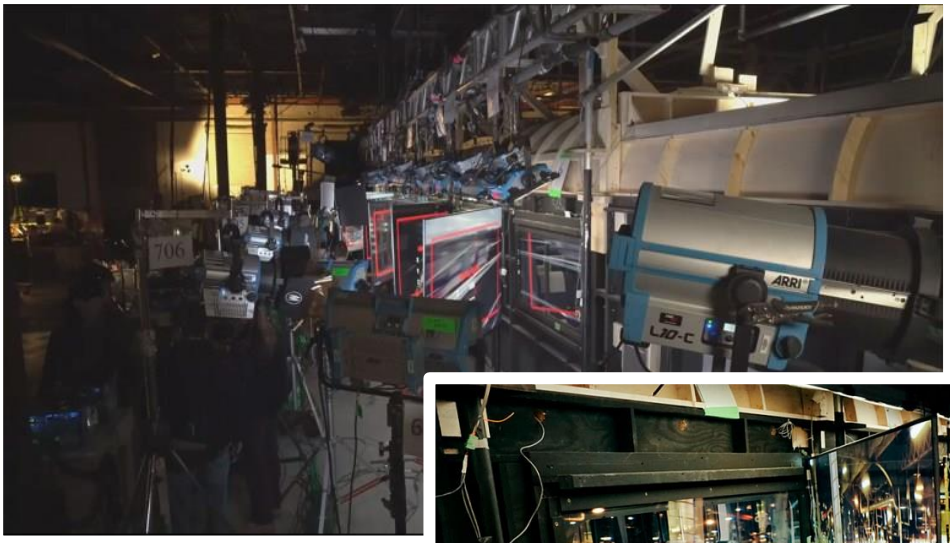
FILM LONDON

Film London's Grid Project has identified eight key unit base locations in London with the intention to install electrical supply cabinets to provide an alternative power source to diesel generators and cut carbon emissions. A pilot trial is currently underway at the first unit location.

Evolving equipment models

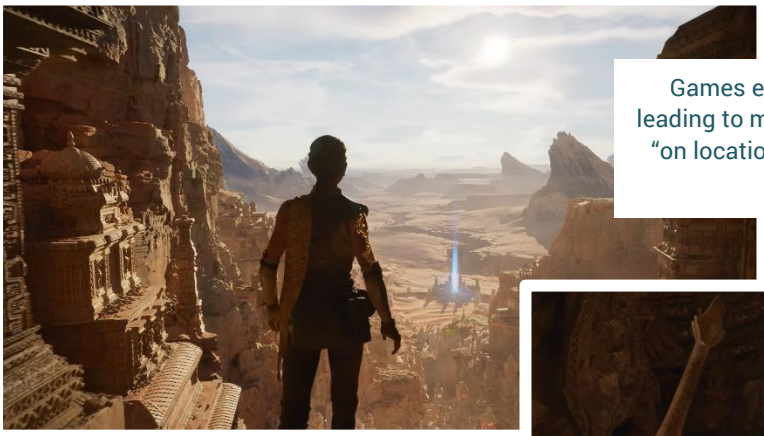
Mitigating the carbon emissions created by other core equipment remains challenging due to the opposing directions of progress. As cameras become smaller and more efficient, lower voltage batteries can be used to power them and will last longer. Conversely, as digital video acquisition formats become more demanding owing to the usage of higher resolutions, frame rates and dynamic range, their power draw and consumption of storage media will increase. To change this, manufacturers will have to realign their metrics of success. This could lead to the emergence of leasing models in which end-users pay a subscription fee for equipment and the manufacturer provides regular maintenance and upgrades over the course of the hardware's lifecycle. Equally, sustainably minded initiatives and productions could advocate for an increased use of rental equipment.

The production industry must redefine best practice to incorporate sustainability as a fundamental principle of decision making to mitigate its impact on the environment and become more sustainable. Production crews must work hand-in-hand with technology manufacturers to achieve this by devising new ways to work that capitalise on the advantages made available to them by new innovations.



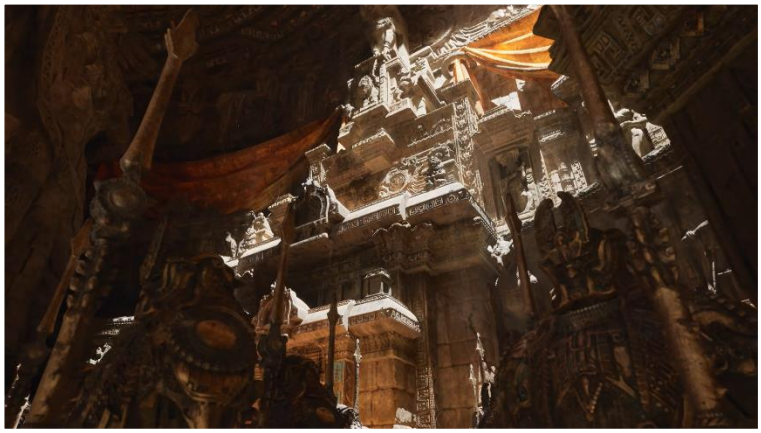
The use of technology reduces the carbon footprint of the film industry. This example illustrates 4K TV screens replicating the outside world from a mock train carriage within the studio environment

Image credit: Stargate Studios



Games engine technology can replicate entire worlds, leading to more sustainable filming, avoiding the need to be "on location". This is a demonstration of Unreal Engine 5

Image credit: Epic Games/Unreal Engine



Case studies across the video supply chain

Data Centre – Boden Type DC One

A 500 kW prototype data centre facility in Boden, Sweden, which uses renewable energy, a combination of free and evaporative cooling with no need for refrigerants, as well as low-carbon, locally sourced building materials. The ultimate goal for the Boden Type DC project is to build a demonstration platform, showcasing the most energy and cost-efficient data centre in the world.

Data Centre – Hulu

Hulu, in partnership with Switch, has recently launched a 100% renewable energy facility spanning 2.4 million square feet across 12 buildings, providing the capacity of up to 55 kW per rack. In addition, the Switch facility is located outside of a fault line in a Seismic Zone 1, ensuring that Hulu will remain operational even in the unlikely case of a natural disaster such as an earthquake.

Renewable Energy – Apple

From a Scope 1 perspective, 100% of Apple's global facilities, including offices, retail stores and data centres, are powered by renewable energy with two-thirds coming from Apple-created projects. With 74% of Apple's carbon footprint coming from manufacturing, 44 of its suppliers have committed to use only renewable energy in the production of Apple devices.

Pre-production & Filming – 1917

First large-scale UK film to gain Albert's three-star certification. Emissions from big budget films are generally large, with everything from generators to catering carrying a significant footprint. To facilitate a carbon footprint reduction, environmental assistants monitored the team through pre-production and filming. Bio Collectors collected food waste and converted it into biogas, electricity, and high-grade fertiliser for agriculture. The team sourced generators, utilising waste vegetable oil, and air travel was kept to a minimum with most travel happening by train.

Cloud – Untold Studios

The only moving image creative studio in the world to be fully cloud based, following a partnership with Amazon Web Services (AWS). The design of the cloud technology infrastructure means that even when working in studio, all employees are effectively working remotely. This means that Untold Studios' team can work from anywhere in the world, while data and workstations are located securely in the UK. Moreover, the approach is entirely scalable and provides virtually unlimited computing power. It can scale up and down as required with no prior notice using only the energy they require. It is also an unlimited and virtualised storage solution, which accommodates for highly complex and data-rich tasks.

5G presents opportunities in sustainability

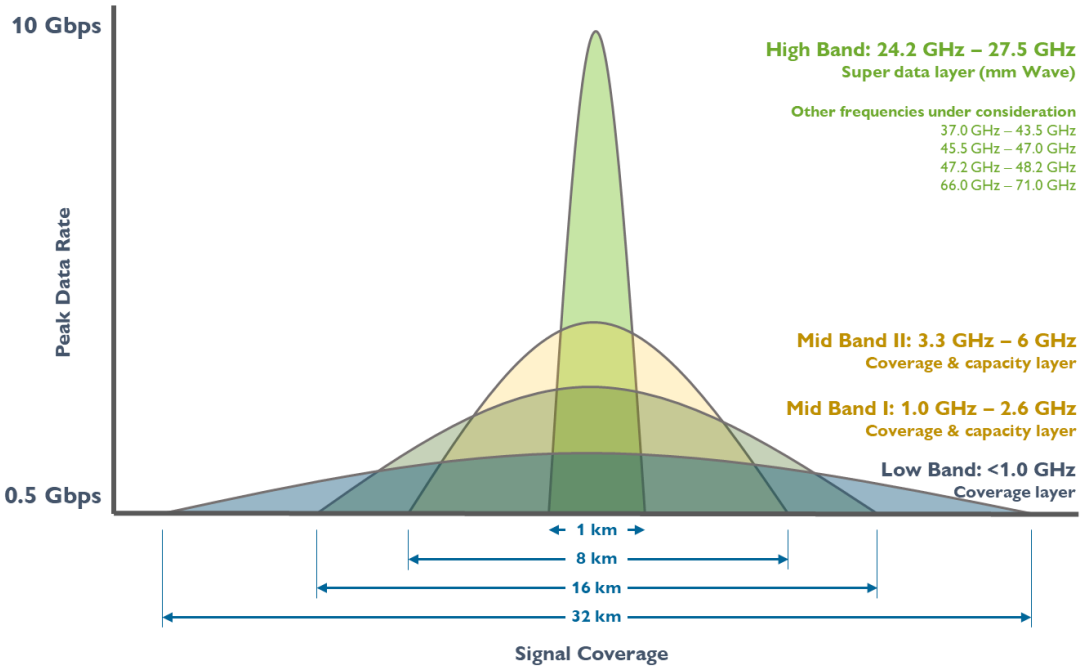
Far from being viewed as just another mobile communication technology, the architecture of 5G networks allows for ultra-low latency and higher bandwidth, leading to commercial applications including broadcast television and video distribution with lower carbon footprint.

What is 5G and why does it matter?

A significant capital investment in infrastructure is underway to fully deploy 5G services. Operators worldwide have embarked upon costly upgrade programmes and are participating in radio spectrum auctions to bring wide coverage of 5G services to commercial reality.

5G promises headline download speeds of up to 10Gbps and this necessitates substantial bandwidth to be made available. Behind the scenes, communications regulators worldwide have collaborated in their spectrum planning to unify frequencies and create opportunity for 5G to flourish. Broad network coverage is required alongside ultra-fast transmission, therefore there are three main frequency bands planned for 5G services.

- Low band: wide network coverage at lower data rates. This can deliver 100 Mbit speeds over a wide area, providing a fivefold increase on current headline rates.
- Mid band: provides the "coverage and capacity" layer, with operators aiming for spectrum centred on 3.5 GHz. This presents an optimal balance between coverage and bandwidth.
- High band: centred on 26 GHz, this adds the "super data layer" providing ultra-high bandwidth service, up to 10Gbps over very short distances. This is commonly known as mmWave.



Beyond headline speeds, the ultra-low latency in 5G effectively brings edge devices and cloud far closer topologically, blurring the boundaries over where compute resource can be placed. This opens up new applications that demand real-time response from cloud services, such as editing suites, with television production and broadcasting equipment set to take full advantage.

Like all infrastructure projects, many will argue that 5G network construction is damaging for the environment, especially considering the massive densification of cell infrastructure necessary to deliver mmWave alongside the associated fibre network that connects each mobile tower. Regardless, the next generation of mobile networks are being built, the number of enterprise applications is expanding, and broadcasters are actively studying how best to harness the enhancements that 5G will bring.

5G set to transform television production

The introduction of 5G looks destined to transform how the video ecosystem operates, especially across live events and film production. Today, broadcasters increasingly utilise wireless networks for a diverse range of tasks, everything from uploading a single news story from the field to transmitting entire remote broadcasts. Much of this has been possible on 4G LTE networks to date, however the migration to 5G networks will significantly enhance the reliability of wireless data transmissions while massively increasing the opportunity for more data-intensive applications, such as point-to-point links that are frequently carried via microwave, fibre or satellite connections.

Bonded cellular technology has emerged as a cost-effective and viable solution for outside broadcast. It operates by combining IP connections over multiple cellular networks, presenting broadcasters with extremely reliable connections and dramatically reduced costs for live video capture and distribution. Using several LTE modems simultaneously, broadcasters can often secure up to 15 Mbps back to master control with sub-second latency. From a sustainability perspective, bonded cellular is being employed in place of traditional distribution and is mitigating the requirement for satellite links provided by diesel-powered outside broadcast (OB) trucks.

Three major features of 5G make it practical for adoption in television production: the gigabit performance; the low end-to-end latency; and most importantly network slicing – new to 5G – that reserves guaranteed bandwidth for broadcast applications. Trials in stadia today make use of 5G transmitters carried in the backpack of the cameraman; these are connected to dedicated, localised receiver antenna arrays erected around

According to BT Sport only around 10% of video captured at a live event is made available for broadcast. 5G allows video to be transmitted directly to studios, enabling more footage to be utilised

the stadium. From there the video stream is routed onto fibre networks and across the internet for relay to production facilities.

5G affords broadcasters the opportunity to relay live video directly to production studios, opening up a wider range of coverage possibilities whilst further reducing costs by minimising the number of technical staff required at each event. For example, due to increased mobility through wireless connectivity, a live event ordinarily covered by eight fixed cameras could instead be covered by four 5G cameras; and production engineers that would ordinarily travel and operate on location can instead work more efficiently from remote studios.

"Once commercial 5G networks are operational, much of the backhaul infrastructure can be dispensed with"

As 5G networks are rolled out more widely, network slicing will be employed on cell towers reserving a protected portion of bandwidth specifically for TV production, carrying the traffic that would ordinarily have been backhauled over satellite links connected via OB trucks. Once commercial 5G networks are fully operational, broadcasters believe that further improvements in sustainability become feasible because much of the complicated and expensive backhaul infrastructure can be dispensed with.

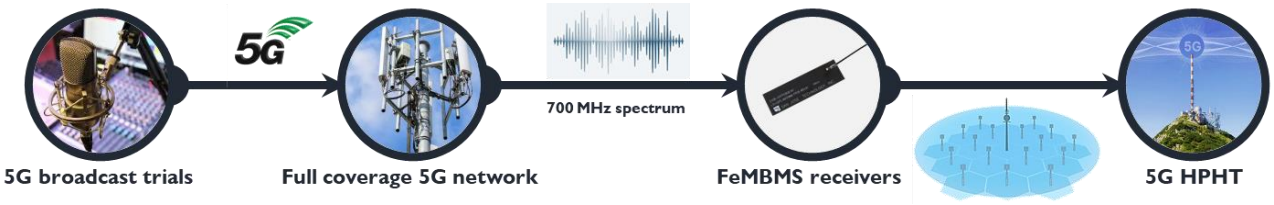
Towards 5G transmission

We are moving to an all-IP world. For TV broadcasters and content providers, 5G creates significant opportunity to broaden their reach across a wide range of end devices; and for consumers, it affords them access to even richer content on their smartphones, tablets and TVs. More importantly, mobile networking standards have evolved rapidly in recent years and now offer the potential to deliver much higher efficiencies than incumbent TV broadcast technologies.

LTE broadcast offers an alternative to traditional satellite, cable and terrestrial television distribution. Trials have discovered that the operating costs for LTE broadcast should be broadly similar to digital terrestrial television transmission, whilst becoming more sustainable over the longer term. The key advantage of LTE broadcast is in enabling video content to be delivered to several users simultaneously using multicast, rather than individual streams over unicast, improving sustainability by optimising network bandwidth usage whilst minimising distribution costs.

LTE broadcast capability is an integral part of the 5G standards. This enables high power high tower (HPHT) applications in 5G to distribute television (and radio) services up to 60 km in radius with 100% of the bandwidth available for broadcasting. New codecs and media formats were added that more closely align with broadcast TV industry requirements; and this has potential to lead into new areas, such as virtual reality (VR) and volumetric video transmission.

Broadcast over 5G is especially interesting for Europe, as there is an immediate deployment opportunity using the 700 MHz spectrum band previously occupied by terrestrial television services. Technical studies conclude this is approximately twice as efficient as DVB-T which would create spare capacity in the spectrum for alternative use cases. Beyond 2030, there is potential for the remaining terrestrial television frequencies to be reallocated to 5G, with TV broadcasts migrating from DVB to 5G LTE broadcast, although this is far from being a guaranteed outcome when cable and satellite offer alternatives.



The opportunity to utilise 5G services reignites the debate over whether 5G LTE broadcast could, or indeed should, replace digital TV broadcasting standards such as DVB-T2 or ATSC 3.0, especially now that UHD, and even HD, broadcast is becoming challenging over diminished terrestrial spectrum. Additionally, C-band spectrum presently used by satellite operators in the US is also being reallocated to mid-band 5G services, further increasing the pressure on broadcast television services.

The overall picture on 5G broadcast is yet to fully develop. Wide support on devices remains a crucial consideration, as this drives the business models that govern when 5G broadcast becomes commercially viable.

Meanwhile, the debate over sustainability raises questions as to why multiple and largely disparate satellite, cable and terrestrial broadcast networks must be run concurrently, especially when further innovation will investigate 5G for other multimedia-rich services, ultimately allowing television, radio and mobile data to share a common infrastructure.

5G offers potential to carry television, radio, and other broadcast services, banishing the requirement for multiple disparate networks

Machine learning and sustainability

Machine learning is beginning to impact on the broadcast solutions market, unlocking a range of opportunities for the industry.

One of the most innovative, but perhaps lesser-known areas is the application of AI to video encoding technology. Machine learning techniques are employed during video encode to reduce file sizes and bit rates whilst maintaining visual quality. A reduction in bit rates leads to significant cost savings in network bandwidth and delivery, alongside corresponding improvements in energy savings in both the data centre and at the receiving device. The technology allows encoders to optimise video encode parameters on a scene-by-scene basis, whilst feeding the results back into the system to enhance future encoding sessions. This may also speed up encoding times and deliver efficiencies in live broadcast. The feedback loop ensures that the AI applies better encode parameters in subsequent sessions, which over time approach the optimum compression for a given scene. Once standards for end-to-end energy measurement are defined, AI-based codecs can leverage this additional data to optimise delivery still further, uniquely selecting encode parameters based specifically upon individual device target.

Another area where machine learning techniques are being applied is in improving accessibility through closed captioning and subtitles. Using algorithms that have been guided through massive language datasets, speech is translated into text in real time and automatically applied to broadcast assets. In addition, machine learning can now identify the context of the speech, and this information is used as metadata to help catalogue video assets. Future iterations may utilise intonation and inflexion to further improve accuracy rates. Efficient cataloguing of video footage enables fast retrieval and discovery, reducing the energy used in search and enabling assets to be reused, potentially avoiding unnecessary video shoots.

Machine learning techniques are being employed to search video for specific content, both audio and visual. Once indexed, portions of the video can be stitched together to automatically produce highlights and show reels which are immediately made available to programme editors. For example, goals during a football game may be discovered by identifying video sequences where the goalmouth is present in the scene and the crowd are cheering. This has an indirect impact in reducing energy costs, as video highlights can be assembled more quickly than relying upon manual operation alone.

Semiconductor vendors are developing the next generation of video decode chips that run neural networks to enhance picture quality, enabling machine learning techniques to be employed in the reconstruction of low-bit rate video streams or to enrich resolution upscaling algorithms on consumer products. In combination with machine learning for encoding, this delivers prospects for entirely new codecs and compression schemes that harness AI to both massively improve efficiency of distribution and further enhance video and audio quality during decode.

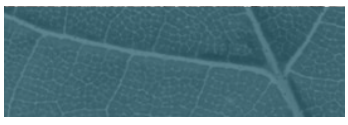
Summary

Video entertainment must adopt an end-to-end approach to its sustainability strategy if the sector is to see its carbon footprint reduce, and eventually become zero. There has been a strew of different approaches to sustainability across the industry so far. Larger firms, especially within consumer electronics, have made significant progress, setting ambitious carbon neutral and carbon negative targets. The film industry and broadcasters, driven by association and government-led initiatives, have also begun their sustainability journeys; and content providers are becoming increasingly aware of their growing carbon footprint as internet traffic increases as a direct result of digital delivery.

Several key events will be pivotal to video entertainment's sustainability journey in the coming decade. The convergence towards IP-based infrastructure is set to change the distribution of television and linear services to users. It will transform methods of production and distribution, with associated benefits in quality, flexibility, and a reduction in carbon emissions. Broadband networks will have the necessary capacity to carry increased traffic, with data bandwidth to homes consistently improving year-on-year to allow IP-based video to proliferate.

Moreover, data centres will increasingly become a key element in the supply chain; indeed, the migration towards IP affords video service providers opportunity to take full advantage of data centres and leading cloud-based infrastructure firms transitioning towards the use of 100% renewable energy. Efficiencies in new video codecs will have a major part to play here, as content catalogues are re-encoded to be both smaller on storage and more efficient in the use of network bandwidth, reducing the energy required to transfer and deliver video assets. Meanwhile, AI and machine learning are now being actively used to dynamically adjust encode parameters, optimising video streaming dependent upon the distribution mechanism. Attention is also being given to embedding AI-based intelligence into codecs themselves, although this is still several years away. Meantime, 5G-based workflows will disrupt industry norms, with untethered 5G cameras providing for increased flexibility in video capture and event coverage whilst 5G networks simultaneously reduce the requirement for outside broadcast trucks, satellite backhaul and local production facilities.

In time, sustainability will become a key pillar in how video entertainment is defined. Through government and sector-specific initiatives, like Horizon Europe and the Green Screen Initiative, providing companies with incentives and grants; green and new technologies becoming more mainstream; certifications and carbon calculators defining an industry norm for measuring sustainability; and consumer awareness of the industry's carbon footprint continuing to grow, there is ample opportunity for the industry to quickly embrace sustainability.



About Futuresource

Futuresource is a specialist research and knowledge-based consulting firm with a 30-year heritage, providing organisations with ongoing insight and forecasting into media & entertainment, broadcast equipment, education technology, consumer electronics, digital imaging, storage media and professional displays.

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