SMPTE Sustainability Working Group

Understanding the environmental impact of Media in the Cloud:

A Discussion Paper

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SMPTE Sustainability Working Group Members:

Dee Davison (Chair) from Deluxe Media at Dee.Davison@bydeluxe.com
Abdul Hakim from DPP at abdul@thedpp.com
Barbara Lange from Kibo121 at bhlange@kibo121.io
Cedric Lejeune from Workflowers at cedric.lejeune@workflowers.net
Hemini Mehta from the European Broadcast Union at mehta@ebu.ch
Jimmy Parker-Barratt from Microsoft at James.Parker-Barratt@microsoft.com
Erik Reinhard from InterDigital at erik.reinhard@interdigital.com

CONTEXT

"Meeting the needs of the present without compromising the ability of future generations to meet their own needs[1]."

This is how the United Nations Brundtland Commission defined sustainability in 1987. Thirty-five years later, sustainable efforts all around the world still strive towards this goal.

The term sustainability is widely used to cover all manner of activities aimed at improving the longevity of something while protecting planetary resources, societal wellbeing, and economic growth.

In 2015, the United Nations Members States collectively adopted a '2030 Agenda for Sustainable Development' which provided a shared blueprint for peace and prosperity for people and the planet, now and into the future.[2] Within this blueprint are 17 Sustainable Development Goals (SDGs) which are a series of ambitious objectives and targets to end extreme poverty and hunger, fight inequality and injustice, and tackle climate change, by 2030.[3]

These Sustainable Development Goals offer anyone new to sustainability visibility as to the breadth and depth of the topic.

Businesses around the world play a vital role in the global transition to a more sustainable world. Corporate sustainability is a topic which is rapidly becoming commonplace at Board tables across all industries. Impetus is being driven by a) the startling shift in climate change and resulting extreme weather events causing disruption and disaster around the world, b) the knock-on risks that this presents to businesses from a safety, workforce and supply chain point of view, and c) expectation from shareholders, customers, employees, vendors, and end users that businesses are taking responsibility for their planetary and societal impacts.

For context, it is important to understand how a corporate carbon footprint is defined. This is commonly presented in "Scopes". Scope 1 includes any greenhouse gas emissions that are released directly into the atmosphere as a result of company activity. It covers company owned or controlled resources for example: company owned fuel powered vehicles; fuel-based generators; machinery utilising gases such as air conditioning and refrigeration, any 'fugitive' emissions from leaks in these systems; and emissions from industrial manufacturing. Scope 2 captures indirect greenhouse gas emissions created as a result of purchasing electricity, steam, heating and cooling for a company's premises. Scope 3 covers the indirect greenhouse gas emissions created from upstream and downstream activities in a business value chain which enable a business to operate. Scope 3 is broken down by the international Greenhouse Gas Protocol

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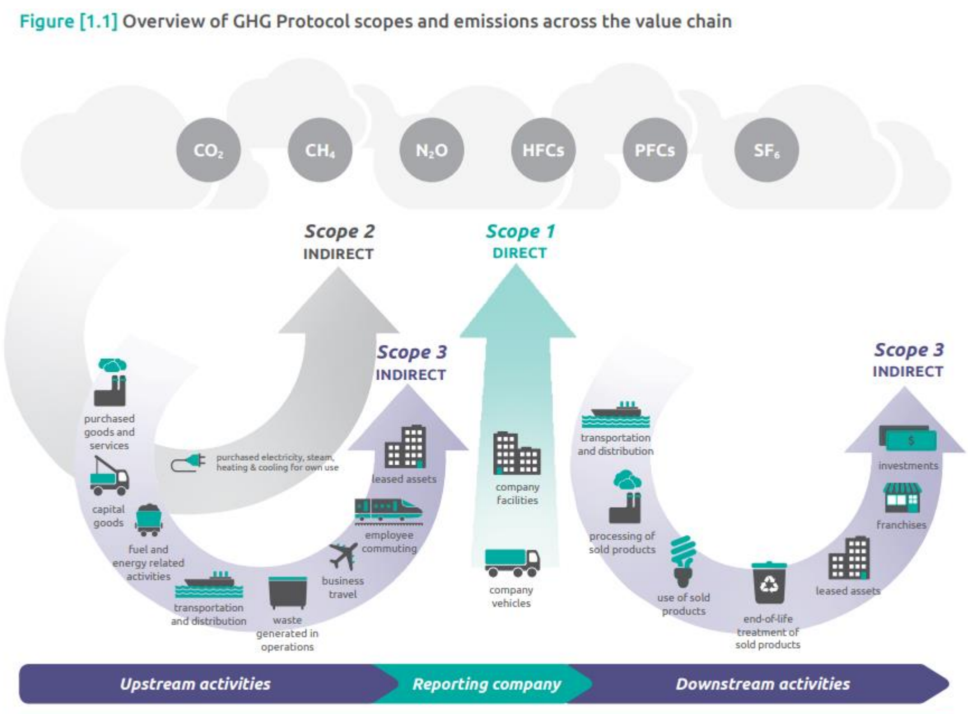
[1] UN (1987) *Report of the World Commission on Environment and Development: Our Common Future*, *http://www.un-documents.net/our-common-future.pdf*.

[2] THE 17 GOALS | Sustainable Development. Available at: https://sdgs.un.org/goals

[3] Blazhevska, V. (2020) *United Nations releases special 2020 broadcast calling for collective action*. Available at: https://www.un.org/sustainabledevelopment/blog/2020/09/united-nations-releases-special-2020-broadcast-calling-for-collective-action/.

into 15 categories these can be seen in the infographic below[4]. There is an abundance of information available online covering Scopes 1, 2 and 3. The Working Group advises that the Greenhouse Gas Protocol[5] is a good place to start for those wanting to learn more.



Source: Greenhouse Gas Protocol Corporate Value Chain (Scope 3) Accounting and Reporting Standard

The 2022 Q2 Gartner Business Quarterly Review[6] publishes the top strategic priority areas for CEOs, sourced from the Gartner CEO and Senior Business Executive Survey 2022. In 2022, environmental sustainability increased 292% in the rankings of top strategic priorities since 2020 and now sits in 8th position. The same review lists environmental sustainability as the 3rd most important driver in the need for new or improved products, with CEOs viewing environmental sustainability as a competitive differentiator.

As we can see, climate change may feature on the risk register of businesses around the world, but environmental sustainability also offers great opportunity for business innovation.

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[4] Greenhouse Gas Protocol (no date) *Corporate Value Chain (Scope 3) Accounting and Reporting Standard*, *https://ghgprotocol.org/sites/default/files/standards/Corporate-Value-Chain-Accounting-Reporing-Standard_041613_2.pdf*. Available at: https://ghgprotocol.org.

[5] *About Us | Greenhouse Gas Protocol* (no date). Available at: https://ghgprotocol.org/about-us.

[6] *Gartner Business Quarterly - Q2 2022 | Case Studies & Articles* (2022). Available at: https://www.gartner.com/en/insights/gartner-business-quarterly/q2-2022.

SMPTE SUSTAINABILITY IN THE CLOUD WORKING GROUP 2022

The SMPTE Sustainability in the Cloud Working Group was established in April 2022 as a part of the SMPTE Media in the Cloud Initiative. In its first meeting the term “Sustainability”, in its widest context, was discussed by the Group and it was agreed that the Group’s remit would focus solely on environmental impact. Consideration of economic and social impacts are therefore out of scope in this report.

The Working Group’s objective is to explore and share information with members on the environmental sustainability of content processing through the Cloud. Sustainability of the cloud has become an increasingly debated topic in recent years. While cloud computing is generally thought to be more efficient in terms of energy usage than ‘on premise’ operations, there are multiple factors affecting efficiencies that are important to understand.

This document attempts to summarise the findings from a collection of publicly available research papers from esteemed authors who have considered this topic in detail. The SMPTE Sustainability Working Group shares the key findings, offers their conclusions on this work to date and their recommendations for where further research may be required.

Case studies are presented under three headings: Content creation; content manipulation and content distribution. The studies reviewed are by no means a comprehensive set of thinking on the topic.

The objective of this paper is to offer a foundational understanding of sustainability and a digestible overview of some of the existing knowledge available on cloud sustainability in the media industry. It is hoped that the media industry will further this knowledge through collaboration and use it as a reference source to influence sustainable business thinking and practice.

For those new to the topic of sustainability, a sustainability glossary has been prepared by the SMPTE Sustainability in the Cloud Working Group which covers common terminology alongside signposting to some of the leading international reference sources on sustainability.

CONTENT CREATION CASE STUDY

3.1.1 IBC ACCELERATOR, SUSTAINABILITY IN LIVE SPORTS

In 2021 the IBC Accelerator programme supported a project looking into the impact of cloud for live productions. This was a cross industry project involving a proof of concept team including, BBC Sport, BT Sport, Sky Sports, NBC Universal, and SuperSport alongside the English Premier League, IMG/Premier League Productions and the BAFTA led sustainability production scheme “albert”. The technology partners were AWS, Blackbird, Hitomu, Microsoft, M2A Media, Singular.live and Zixi.

The project set out to compare the carbon impact of traditional and remote workflows for live production in the hope that the trial would demonstrate ways for broadcasters to move towards a net zero carbon future for live productions.

SCOPE AND LIMITATIONS

The project team compared the carbon footprints of a traditional outside broadcast (OB) and a bespoke cloud-based workflow for delivering the Premier League game between Liverpool and Newcastle United on 16th December 2021.

The technical infrastructure for both traditional OB and cloud workflows is described here: [Sustainability in Live Production: The Premier League shoots for net zero | Industry Trends | IBC]

FINDINGS

Prior to this project, Sky Sports and other broadcasters had found that remote production, when compared to traditional workflows, can reduce the number of crew travelling to site by up to 50%.[7] This project demonstrated additional savings, of over 50%, in the amount of onsite fuel required when utilising cloud-based workflows. The smaller onsite presence also allowed teams to use smaller OB trucks which reduced CO2 impact further (the trial achieving 5% reduction in CO2e tonnes). Furthermore, the technical infrastructure for the gallery production was reduced by up to 70% by utilising cloud-based software.

While these findings showed that the cloud workflow was less energy intensive than traditional production workflows. The added benefits reported went further than just emission results.

- The cloud-based production was seen to offer more opportunities for "affordable, easily updatable and more scalable production resources, enabling a team to easily add equipment when additional cameras are required."[8]
- The accessibility of cloud based software from a crew perspective was also thought to be beneficial in some cases offering improved work life balance and a broader talent pool from which to recruit from.
- Replacing hardware with software was better for the planet in terms of reducing e-waste. However, cloud workflows of course are still utilising hardware, albeit it in a different location.
- The ability for multiple feeds to reach feed-takers around the world for live events could greatly reduce the carbon footprint of third parties who would typically send crews from multiple locations around the world to a live site.

It was not all plain sailing however, there were limitations in the bandwidth capabilities to cope with more than a few camera feeds and the wraparound match programming was harder to deliver in the cloud. Gordon Roxburgh, Head of Production Technology, Sky Sports/Sky Production Services stated[9]: "We can now work with the vendors and the background techs to understand ….. How do we push it towards being a 25-camera broadcast, which is what a top end Premier League match requires….We can't spend the hour

[7] Ringrose, F. (2022) *Sustainability in Live Production: The Premier League shoots for net zero*. Available at: https://www.ibc.org/features/sustainability-in-live-production-the-premier-league-shoots-for-net-zero/8591.article.

[8] Ringrose, F. (2022) *Sustainability in Live Production: The Premier League shoots for net zero*. Available at: https://www.ibc.org/features/sustainability-in-live-production-the-premier-league-shoots-for-net-zero/8591.article.

[9] Ringrose, F. (2022) *Sustainability in Live Production: The Premier League shoots for net zero*. Available at: https://www.ibc.org/features/sustainability-in-live-production-the-premier-league-shoots-for-net-zero/8591.article.

before the match talking to people at different venues and all around the stadium, bringing this person in, throwing to co-commentators, rolling in the VT, doing the analysis. That's the hard piece...."

Charlie Cope, Technical Executive, BBC Sport commented on these challenges in the study too[10] "These things always throw up challenges, and for us the two main ones were around the edit-while-record workflows – fast-turnaround content whilst still in record is always challenging – and around audio handling. There are multiple audio channels we use to exchange content in the Premier League domain, where we've got multiple commentaries and different audio options flying around. That is always challenging to handle in the IP streaming domain - but certainly something we now have a good handle on from this PoC."

CONTENT MANIPULATION

Many media businesses have now adopted cloud-based working in content manipulation, by which we mean the process of preparing content for distribution for example; editing, mastering and transcoding. As a trend, this way of working was accelerated by the global Corona Virus pandemic in 2020. Rowan de Pomerai from the DPP confirmed this view in the paper 'The Cloud for Media' in 2020 which states "Increased demand for location independence is a driver for cloud migration."[11]

While many COVID driven transitions to the cloud have since become business as usual, the sustainability impact of this shift, so far as the Working Group can see, has been less well documented. We consider two case studies in this section, one assesses energy consumption of Amazon AWS EC2 instances and embodied carbon emissions in hardware, the other provides a view of the carbon impact from ITV's transition to cloud for their live daytime TV editing workflows.

3.2.1 BUILDING AN EC2 CARBON EMISSIONS DATASET

An article published in Teads Engineering on 23 September 2021 by Benjamin Davy[12] provides insight into a study on the power consumption and resulting emissions from Amazon Web Services EC2 instances. AWS Elastic Cloud Compute (EC2) is a dynamic cloud computing platform often used to process media. The research project was inspired by Cloud Carbon Footprint, David Mytton, Boavizta, Workflowers and Hardbricks. The study is included in this section because of its contextual relevance to running EC2 instances in the cloud for remote content manipulation for example, post production, effects, editing and mastering packages. Of course, the data could also be applied to other parts of the content chain.

[10] Ringrose, F. (2022) *Sustainability in Live Production: The Premier League shoots for net zero*. Available at: https://www.ibc.org/features/sustainability-in-live-production-the-premier-league-shoots-for-net-zero/8591.article.

[11] *The Cloud for Media* (2020). Available at: https://www.thedpp.com/cloud.

[12] Davy, B. (2022) *Building an AWS EC2 Carbon Emissions Dataset - Teads Engineering*. Available at: https://medium.com/teads-engineering/building-an-aws-ec2-carbon-emissions-dataset-3f0fd76c98ac.

SCOPE AND LIMITATIONS

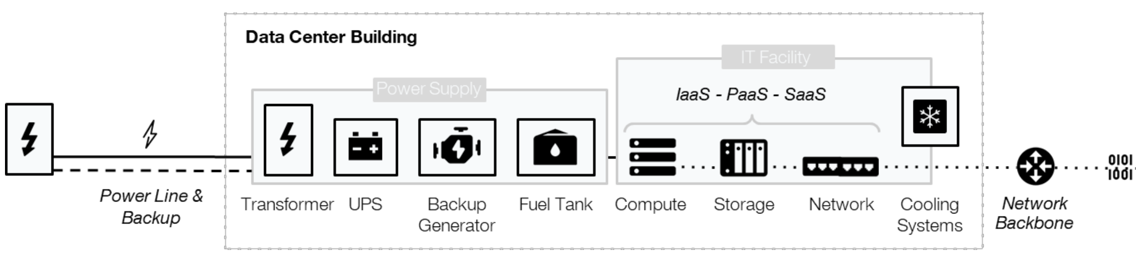
The team studied the power measurement variations from different levels of CPU on EC2 instances and then validated their assumptions through on-premise experiments aimed at recreating an EC2 environment and measuring energy consumption using energy watt meters.

The results were then used to make assumptions of the power consumption profiles of all EC2 instances, even though the team were not able to measure each instance in the lab environment.

The study also provides insight into how carbon emissions are calculated and offers a proposal for estimating embodied emissions for EC2 hardware.

The research only addresses the compute part of the datacentre workflow. As you can see from the simplified diagram below, this is only one part of the process albeit an important one for customers to understand as it is where the power draw is required for customers' dedicated workloads.

The study considered the payment bills as the reference point for usage of the EC2 service and it did not take account of any hardware being *partially* utilised, which is likely to be the case at least some of the time. "Our methodology doesn't take into account situations where we would be the only tenant on a physical machine and only "use" a limited portion of its resources. In that case, the rest of the resources would be idle, consuming power but not accounted for in our simple model."[13]



SIMPLIFIED DATA CENTER SERVICE BY BENJAMIN DAVY[14]. ICONS FROM FREEPIK AND ICONS8.

FINDINGS

A software tool called 'turbostress' was created to measure the power consumption of EC2 instances with different CPU loads.

To validate the software readings an on-premise laboratory was set up to measure the actual energy readings for the same EC2 instances. This showed that the turbostress software and on-premise tests were broadly in line, with minor differentials suspected to be fan, storage and network card consumption which

[13] Davy, B. (2022) *Building an AWS EC2 Carbon Emissions Dataset - Teads Engineering*. Available at: https://medium.com/teads-engineering/building-an-aws-ec2-carbon-emissions-dataset-3f0fd76c98ac.
[14] Benjamin DAVY | LinkedIn

would not have been picked up by software readings. This is a positive result as it means that software can be used to make a good approximation of the power consumption of hardware.

Based on these findings the power consumption for other CPU types were able to be estimated along with other components including GPUs and, based on assumptions, the 'other' components drawing energy as previously mentioned; fans, storage drives and network cards.

Carbon calculations were made using electricity carbon emission factors from the location of each datacentre and included a Power Usage Effectiveness (PUE) at 1.2 for AWS. A Carbon Footprint *Estimator*[15] for the EC2 instances modelled has been made publicly available by this study. The limitations of the methodology and calculations are clear and transparent in the report[16] and should be clearly understood before utilising the data.

With reference to embodied emissions, the study offers a table of hardware models and their manufacturing footprint reported between 2019 and 2021. Some interesting observations are made from this work, notably that "manufacturing emissions cannot be correlated to the weight of the machine, which could confirm that most of the carbon footprint is linked to semiconductors rather than chassis or other heavy parts."

A very high-level estimation of typical emissions from the manufacturing process of different hardware components is provided by this study. However, these are based on very broad assumptions and labelled by the authors as a "naïve proposal, while waiting for a better solution".

The article also references the importance of the wider planetary impact of hardware. The Working Group agrees that a holistic view of sustainability must be taken when assessing the 'green' credentials of a product or service.

"Udit Gupta et al. have pointed out the limitations of only focusing on carbon emissions: "Environmental impact of computing systems is multifaceted, spanning water consumption as well as use of other natural resources, including aluminium, cobalt, copper, glass, gold, tin, lithium, zinc, and plastic."[17] By only looking at a "carbon KPI," we could be tempted to regularly move our workloads to newer and more energy-efficient instances and somewhat neglect the other impacts involved with manufacturing this new hardware."[18]

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[15] *AWS EC2 Carbon Footprint Dataset* (2021). Available at: https://docs.google.com/spreadsheets/d/1DqYgQnEDLQVQm5acMAhLgHLD8xXCG9BIrk-_Nv6jF3k/edit.

[16] Davy, B. (2022) *Building an AWS EC2 Carbon Emissions Dataset - Teads Engineering*. Available at: https://medium.com/teads-engineering/building-an-aws-ec2-carbon-emissions-dataset-3f0fd76c98ac.

[17] Gupta, U. (2020) *Chasing Carbon: The Elusive Environmental Footprint of Computing*. Available at: https://arxiv.org/abs/2011.02839.

[18] Davy, B. (2022) *Building an AWS EC2 Carbon Emissions Dataset - Teads Engineering*. Available at: https://medium.com/teads-engineering/building-an-aws-ec2-carbon-emissions-dataset-3f0fd76c98ac.

3.2.2 IBC 2022 TECHNICAL PAPER – ITV & MICROSOFT[19]

In April 2020, as a result of the pandemic, ITV's edit for live team had to move to around 75% remote working. With the success of this shift and a wholesale movement towards a 'sustainable new normal'[20] technology teams started to design a more permanent cloud solution which provided remote edit capabilities and solved the long-standing question of resilience i.e. what would happen if edit teams had to leave the company building at short notice.

SCOPE AND LIMITATIONS

The requirement was for a bespoke production environment to enable long term resilient remote editing. The solution was created by ITV Cyber and Enterprise Common Platform teams in collaboration with Microsoft, Accenture, AVID, Telestream and Support Partners.

The new remote production environment was tested on a pre-recorded show before it was used to create live transmission content in the cloud.

The remote edit environment could not recreate the one-to-one edit suite experience, but by supplying two virtual machines to facilitate collaboration between editor and producer, the creative experience was not all lost. From a security standpoint, the team undertook pen testing to ensure adequate levels of protection within the Cloud environments.

FINDINGS:

In creating this solution ITV found cloud to be a more environmentally friendly means of editing. Moving to the cloud for this project is forecast to save ITV 40,866 kg of CO2e over 5 years.

They commented: "…it puts an end to that traditional routine cycle of buying a non-recyclable asset, powering it, cooling it and using it before disposing of it."

The study also found benefits in the reduction of office space required for edit bays; improved resilience of systems in a Disaster Recovery situation; and, from a cost perspective a cloud subscription reduces the reliance on Capex cycles to keep company owned hardware relevant.

Adapting and keeping up with software releases was also made easier alongside the ability to scale at pace within a cloud environment without having to purchase, ship and install hardware directly.

[19] *IBC2022 Tech Paper: Post-pandemic adoption of cloud-hosted environments for video editing & tv production* (2022). Available at: https://www.ibc.org/technical-papers/ibc2022-tech-paper-post-pandemic-adoption-of-cloud-hosted-environments-for-video-editing-and-tv-production/9224.article.

[20] *IBC2022 Tech Paper: Post-pandemic adoption of cloud-hosted environments for video editing & tv production* (2022). Available at: https://www.ibc.org/technical-papers/ibc2022-tech-paper-post-pandemic-adoption-of-cloud-hosted-environments-for-video-editing-and-tv-production/9224.article.

CONTENT DISTRIBUTION

There has been a good amount of focus across the industry on the environmental impact of content distribution and this work continues. The SMPTE Sustainability Working Group considered 3 case studies on this topic, summaries of which follow.

3.3.1 BBC RESEARCH AND DEVELOPMENT WHITE PAPER – USING BEHAVIOURAL DATA TO ASSESS THE ENVIRONMENTAL IMPACT OF ELECTRICITY CONSUMPTION OF ALTERNATE TELEVISION SERVICE DISTRIBUTION PLATFORMS[21]

A BBC R&D Whitepaper was published September 2020 [WHP 372], it presents an "assessment of electricity used for distribution and viewing of television over different distribution platforms - terrestrial, satellite, cable and online streaming".

The BBC was used as the reference candidate for this study. Results were presented in two "functional units"

i) the unit used to assess the demand placed on the UK electricity system was the delivery and viewing of one year of BBC TV to the UK population.
ii) the unit used to assess the energy intensity of different distribution platforms was the energy intensity of the provision of one hour of video content to a viewer.

SCOPE AND LIMITATIONS

In scope of this study was the preparation, distribution, and consumption of content. The specific start and end points for each of these stages are well documented in the study.

The study did not factor in emissions from the production of content, the manufacture of DVDs, the manufacture of infrastructure, hardware and devices or the launch of broadcast satellites.

With reference to the utilisation of cloud infrastructure, BBC stores master content and encodes videos for streaming at data centre facilities. The report states that "The elastic nature of cloud services – meaning they can be scaled up at times of higher demand and reduced at other times – is helpful in dealing with peak periods such as the preparation of multiple early-evening regional news bulletins, and reduces overall energy consumption for encoding."

The BBC also use Content Delivery Networks (CDNs), to store prepared original content at locations around the country, enabling faster delivery to audiences and reduced demand on the core network.

[21] Schien, D. *et al.* (2020) *Using Behavioural Data to Assess the Environmental Impact of Electricity Consumption of Alternate Television Service Distribution Platforms*. BBC. Available at: https://downloads.bbc.co.uk/rd/pubs/whp/whp-pdf-files/WHP372.pdf.

KEY FINDINGS

The paper provides BBC emissions generated across its different distribution platforms and presents this as a proportion of all UK electricity in 2016.

It confirms that the highest energy consumption is in the home from set top boxes and TV sets. There is a recommendation that future improvements could be made by collaborating with manufacturers in this space and by moving to a "thin client" model whereby processing occurs elsewhere, close by, but can serve several households collectively.

The study found that when looking at average energy consumption per device hour of viewing, the iPlayer (the BBC's online video on-demand and streaming service) was most intensive, followed by satellite, then cable, and lastly terrestrial which was a good deal less intensive than all of the above. The energy consumption and emissions per device hour are in Figure 1[22]:

Platform	Energy Consumption (kWh/device-hour)	Carbon Emissions (gCO2e/device-hour)
iPlayer – (VOD, Streaming)	0.19	98
Satellite	0.16	82
Cable	0.15	78
Terrestrial	0.06	31

When looking more closely at the results of the iPlayer platform. The annual energy consumption for iPlayer distribution was broken down into:

- wifi modems and routers accounting for 48% of energy;
- networks inside and outside the home (including cable, access and cell networks) accounting for 31% of energy;
- viewing devices accounting for 20%, largely down to the iPlayer service having more people viewing on smaller devices with lower power consumption.

An important finding of interest to the SMPTE Working Group was that server usage, including encoding and CDNs, was marginal at 1% of annual energy consumption for running the platform.

The conclusions of this paper suggest that carbon footprint of on-demand streaming should be explored further. Considering the current energy intensity per device-hour for streaming being the highest across all platforms, and with streaming consumption volumes expected to increase, there may be advancements in viewing technology and formats, hardware and distribution infrastructure that can improve the environmental performance of this platform. The structure and location of CDNs alongside the option for multicasting over IP for efficient distribution of linear channels to receivers simultaneously were added as specific areas for consideration.

[22] Schien, D. *et al.* (2020) *Using Behavioural Data to Assess the Environmental Impact of Electricity Consumption of Alternate Television Service Distribution Platforms*. BBC. Available at: https://downloads.bbc.co.uk/rd/pubs/whp/whp-pdf-files/WHP372.pdf.

In 2021, the BBC revisited their 2016 research to update the carbon emission estimations for the 2019/2020 fiscal year.[23] For their first functional unit, which calculated the demand placed on the UK electricity system from the delivery and viewing of one year of BBC TV to the UK population, they found an 11% energy reduction and a 47% carbon saving between 2016 and 2019/20. This notable reduction in emissions was primarily a result of the increased decarbonisation of the UK electricity grid. The reduction in energy use, despite a 14% increase in total viewing hours from the 2016 study, was said to be a result of more efficient set top boxes. The reduced power consumption of set top boxes, along with increased viewing hours, meant that the iPlayer's energy intensity fell between 2016 and 2019/20. The BBC blog states:

"BBC iPlayer showed the biggest decrease in energy intensity by 42%, followed by satellite at 27%, cable at 21% and terrestrial at 13%."[24]

The energy consumption comparison between 2016 and 2019/20 is captured in Figure 2. Note that the more recent study added a fifth platform for IPTV to capture viewing on YouView, Plusnet and TalkTalk set top boxes:

Platform	Energy Consumption 2016 (kWh/device-hour)	Energy Consumption 2019/20 (kWh/device-hour)	Carbon Emissions 2016 (gCO2e/device-hour)	Carbon Emissions 2019/20 (gCO2e/device-hour)
iPlayer – (VOD, Streaming)	0.19	0.11	98	33
Satellite	0.16	0.12	82	36
Cable	0.15	0.12	78	36
Terrestrial	0.06	0.06	31	17
IPTV		0.11		32

3.3.2 THE CARBON TRUST REPORT ON THE CARBON IMPACT OF VIDEO STREAMING – JUNE 2021[25]

This comprehensive white paper takes an in depth look at the carbon impact of distribution and viewing of video on demand streaming and discusses the challenges, uncertainties and variability involved in estimating carbon impact.

SCOPE AND LIMITATIONS

[23] *The carbon impact of streaming: an update on BBC TV's energy footprint.* (2021) Available at: https://www.bbc.co.uk/rd/blog/2021-06-bbc-carbon-footprint-energy-envrionment-sustainability
[24] *The carbon impact of streaming: an update on BBC TV's energy footprint.* (2021) Available at: https://www.bbc.co.uk/rd/blog/2021-06-bbc-carbon-footprint-energy-envrionment-sustainability
[25] *Carbon impact of video streaming* (2021). Available at: https://www.carbontrust.com/resources/carbon-impact-of-video-streaming.

The scope includes operational emissions from distribution and viewing of content. It doesn't consider upstream emissions from content creation or embodied emissions in hardware.

The measured components were data centres, CDN, internet transmission, home router, end user viewing device (TV/laptop) and TV peripherals (set top boxes).

National average emission factors were used to calculate the carbon impact in this paper, the results do not factor in renewable energy sourcing of data centres, network providers or in people's homes. There is a very useful description of energy usage from data networks, including two separate methodologies for allocating network emissions and the pros and cons of each.

Variability is seen across the results according to temporal, geographical and technological factors. Uncertainty in network emissions also arises from the differences in allocation methodology used.

This study covers the DIMPACT video streaming methodology for carbon assessment. In October 2022 DIMPACT published a Methodology White Paper[26] which details the scope and boundaries of their carbon assessment methodology across three modules: video streaming, digital publishing and online banner advertising. Each module includes measurements of data centre processes, internet network infrastructure and end user devices. This is a very useful paper for anyone in content distribution to gain greater understanding about how to measure the carbon impact of digital services.

FINDINGS

In tune with the BBC study, this report found end user devices to be the most significant contributors to emissions when considering distribution and viewing of video on demand. Routers and screens together accounted for 84% of emissions from one hour of video streaming. By way of comparison, data centres in this model accounted for 1% of total emissions, the remainder falling to transmission networks (10%) and TV peripherals (5%).

Using average European emission factors, the study estimates approximately 55g of CO2e is created per hour of streaming. For reference, the study offered a comparison of 16g CO2e from microwaving popcorn for 4 minutes and 22g of CO2e from driving a petrol car 100m. The viewing device is an important factor in variability of emissions with a 50 inch TV generating 4.5 times more energy than a laptop and 90 times more than a smartphone.

The mix of energy in each national or regional grid also vastly affects the results. To illustrate, at the time of the Carbon Trust report being published, Germany's emission factor was 25 times that of Sweden. Territory average emission factors should therefore be viewed with caution.

The Working Group found the two methodologies modelled for calculating network emissions of particular interest. These were:

- average energy per data volume (kWh/GB)
- baseload power allocated per user and marginal added energy for data volumes

[26] *Methodology* (2022). Available at: https://dimpact.org/methodology.

The average energy per data volume is a more commonly used method for billing and customer reporting of data transmission emissions.

However, the Carbon Trust paper cites detailed research conducted by Jens Malmodin on networking emissions and states:

"Malmodin's proposed power model offers a more accurate reflection of the instantaneous and short-term effect of video streaming on network energy consumption. The power model makes use of a baseload and dynamic component power model in accounting for the internet transmission related energy of networks and more closely represents the always on state of network equipment and energy consumption, compared to a conventional average kWh/GB factor."[27]

The baseload power methodology means that volume of data does not directly correspond to increased energy consumption of networks. Supporting this view, the study shares that telecom network operators only reported a marginal (less than 1%) increase in energy consumption during the pandemic, despite increases in data traffic of up to 50% (GSMA 2020).

Furthermore, distributing higher content resolutions were also found to have marginal impact on emissions when considering the baseload power methodology:

"The higher bitrate required to watch an hour of video streaming in 4K (2160p) compared to Full HD (1080p) requires additional electrical power, but only marginally so relative to baseload power consumption."

The supporting power and data models from Malmodin's study, shared in Figures 22 and 23 of the Carbon Trust report, illustrate this point based on 4G radio units and the fixed broadband lines in households. It would be interesting to see results of these models applied to the entire network transmission chain. The Carbon Trust report notes that the baseload power model would also need to include idle energy consumption to ensure all energy is accounted for.

When transmitting a single data package the emissions calculated via the baseload power methodology were found to be less impacted by package size. However, would it be fair to assume that increasing volume of data traffic across a whole location or user base over time would mean networks could reach saturation point? The Working Group consulted Jens Malmodin on this specific point and were interested to learn that, for general household use, networks typically provide more than enough bandwidth and equipment capacity only tends to become a problem when it gets too old. As network infrastructure is upgraded, new equipment generally provides a higher load capacity for a lower power consumption, thus constantly increasing availability to end users. In 2020 demand for data increased so quickly that a lot of equipment was upgraded which in turn led to a total *decrease* in power despite a lot *more* data going through the wires.[28]

[27] [27] *Carbon impact of video streaming* (2021). Available at: https://www.carbontrust.com/resources/carbon-impact-of-video-streaming.
[28] Jens Malmodin, 18.10.22 - email

The International Energy Agency (IEA) further supports this point and directly references Jens Malmodin's research on the topic. They state[29]:

" The energy efficiency of data transmission has improved rapidly over the past decade: fixed-line network energy intensity has halved every two years in developed countries, and mobile-access network energy efficiency has improved by 10-30% annually in recent years."

However, the IEA are also clear that more effort is needed if the sector is to align with the net zero by 2050 goal.

3.3.3 LOCAT QUANTITATIVE STUDY OF THE GHG EMISSIONS OF DELIVERING TV CONTENT[30]

The LoCaT project was initiated by several European organisations active in the TV and broadcast industry, including Television Numerique Terrestre (TNT), Broadcast Networks Europe (BNE), the ORS Group, Quadrille Ingénierie, and Salto Systems, who have commissioned Carnstone, a management consultancy specialising in sustainability and corporate responsibility, to produce a report comparing the greenhouse emissions of various content delivery methods in Europe.

SCOPE AND LIMITATIONS

The report compares the emissions impact of different methods of TV distribution covering, linear TV via Digital Terrestrial Television (DTT), managed IPTV as well as streaming and on-demand viewing, i.e. over-the-top (OTT) services. The latter are comprised of subscription video-on-demand (SVOD) and broadcast video-on-demand (BVOD).

The focus of the study is on the impact of transmitting data, and therefore only peripherally considers content production and end user display devices.

This study modelled a complex system, which comes with inherent uncertainties. Specifically, and in agreement with the Carbon Trust Paper, the lack of accurate data for IP network energy consumption and limited viewing data for end user devices. The study called for more transparency from organisations holding primary data in these areas. They also recommend that national-level bodies who research TV viewing behaviour should look more broadly at viewership of VOD as well as linear and time-shifted content.

[29] IEA (2022) *Data Centres and Data Transmission Networks Tracking Report* Available at: https://www.iea.org/reports/data-centres-and-data-transmission-networks

[30] Carnstone (2021) *Quantitative study of the GHG emissions of delivering TV content*. Available at: http://www.ors.at/fileadmin/user_upload/ors/downloads/LoCaT-Final_Report-v1.2-Studie-Energieverbrauch-Antennen-TV-2021.pdf.

The Working Group were pleased to learn that Ofcom have since commissioned Carnstone to produce a report comparing the energy consumption of DTT and OTT services. The report[31], published on 28th October 2022, confirms the findings of the LoCaT, Carbon Trust and BBC White Paper's referenced above. Carnsone found that approximately 89% of energy consumed for OTT, and 97% of energy consumed for DTT, came from household viewing devices and in-home networks. However, their viewer data illustrated that households viewing DTT in the UK typically watched 4.7 hours of TV per day, more than twice that of the typical OTT household. The report also points to the complexity of calculating network energy intensity noting the fact that terrestrial networks are shared with radio and other data services and internet infrastructure is shared with web browsing, gaming, e-commerce and video conferencing. Applying the commonly accepted attribution method, as referenced by the Carbon Trust paper, is the most established route for estimation of these internal and external transmission networks.

FINDINGS

The LoCat study agrees with the BBC white paper findings that linear DTT requires an order of magnitude less energy than OTT and managed IPTV. Excluding the energy consumed by the television itself, in 2020 across Europe the energy consumption for one device viewing hour was estimated to be 14 Wh for DTT, 109 Wh for OTT and 153 Wh for managed IPTV.

Furthermore, and in line with both the Carbon Trust and BBC papers, the study finds that most energy for TV viewing is consumed by in-home devices. DTT delivery is more energy efficient, especially in situations where the aerial signal does not require active amplification. Whereas managed IPTV requires in-home use of a modem-router as well as a set-top box, which consume greater amounts of electricity.

The case studies are consistent in the key findings about efficiency of viewing devices as well. In general, the larger the viewing device the more emissions generated. So, as previously noted, a 50 inch TV will generate more emissions than a tablet or smartphone being used to view content.

As with most emission-based studies, there are several factors which vary the result, specifically, the location of content start and end points, the type of energy mix in a particular region, and any renewables sourced by the supply chain. The use of CDNs and multicasting over IP can also impact results as well as the viewing behaviour of audiences.

SUMMARY OF KEY FINDINGS

- Based on the studies reviewed, the upstream logistics and technical infrastructures and downstream devices were found to be the more energy intensive parts of our workflows from content creation to distribution.

[31] Carnstone (2022) Carbon emissions of streaming and digital terrestrial television - Ofcom Available at: https://www.ofcom.org.uk/research-and-data/technology/general/carbon-emissions-of-streaming-and-digital-terrestrial-television

- For content creation, cloud production technologies brought reductions in carbon footprint when compared to a traditional live production broadcast by reducing crew travel, onsite fuel requirements, the size of OB trucks and the gallery technical infrastructure.

- The flexible nature of cloud computing was found to be beneficial enabling scaling up or down at pace, but there were limitations in the bandwidth capacity to process multiple camera feeds and manage multi layered edit-while record workflows.

- Other benefits beyond carbon reduction were reported, including the ability for crew to work remotely on live events, opening the door to broader talent pools and improved work life balance. However, this view does vary depending on the type of production and crew preference with some people preferring the immediacy and comradery of onsite teamwork. Furthermore, the Sustainability in News and Sports Panel[32] at IBC on 10th September 2022, commented on the value of the "experience" of live events, stating that operators are often drawn to their line of work from a passion for music, news correspondence or live sports. They want to be at the event. While moving to completely remote crews may not be the answer for all, being able to reduce to a skeleton crew for events will still have a positive impact on travel emissions.

- For content manipulation, the ITV and Microsoft study demonstrated carbon reduction by moving to cloud-based workflows. However, the creative collaboration between editors and producers was harder to recreate in remote settings.

- Software can accurately assess the power consumption of hardware, as shown by the cloud compute emissions study of AWS EC2 instances. The carbon calculator tool made publicly available from this study could be relevant to anyone using EC2 provided the assumptions used to build the data are fully understood.

- The environmental impact of content distribution to TV audiences is a more fully researched topic to date. All three studies reviewed agreed on the following points:

  - In home devices are the most energy intensive component for distributing content to audiences. Set top boxes and modems are the highest consumers making IPTV and OTT platforms bigger energy consumers than satellite and terrestrial.

  - Terrestrial TV is the most energy efficient method of content distribution largely due to the passive home aerial signal and the multi-cast model of terrestrial distribution.

  - Network emissions are noteworthy but measuring these accurately remains a challenge. The Carbon Trust study showed that volume of data does not directly correspond to energy intensity in networks, therefore, they also state that bitrate has a marginal impact on energy

[32] *IBC Content Agenda* (2022). Available at: https://show.ibc.org/content-programmes.
Moderator: Robin Cramp, Production Park, Speakers: Lucy O'Brien, EMG; Alex Dinnin, Warner Bros. Discovery Sports Europe; Gordan Castle, The Meadowdale Group.

consumed by core and access networks[33]. This is not to say data volume is irrelevant. Pricing models typically utilise data volume as a charging methodology and as networks are upgraded over time, infrastructure may need to be replaced, adding more embodied carbon from the manufacture, shipping, and installation of updated technology.

We have seen that cloud usage can bring emissions reduction opportunities. However, when exploring such opportunities, is it vital that customers work closely with their cloud providers to understand the environmental context of the data centres they are using. By this we mean:

- The type of energy powering third party data centres. It is important to ask cloud providers if they are using renewable energy via purchased and/or offset renewables or self-consumption renewables e.g. solar. Purchased or self-consumed renewables allows you to 'offset' your own energy usage with the renewables you generate or buy into. This offsetting of emissions is usually passed down to customers, which for reporting purposes may be helpful, but is not a reason to deprioritise your energy usage in the cloud.

- Data centres are huge consumers of electricity, so it is important to know what tools exist to enable you to proactively manage your usage from both a cost and energy perspective to ensure the most efficient use of cloud facilities. Bear in mind that clouds being multi-tenanted spaces may be set to achieve maximum density of throughput in minimal space, having knock on effects to energy for cooling.

- Some cloud providers are already *carbon neutral*. Many cloud providers have publicised goals towards *net zero*. Please see the glossary for the important difference between these two terms. The key point here is that net zero goals are the priority in terms of giving us any chance of remaining within the 1.5 degree Celsius goal as stated in the Paris Agreement. Offsetting of emissions is important but should certainly not replace reduction plans. The International Telecommunication Union stated this plainly in their Opinion 104, published in October 2022:

  "broadcasters and broadcasting related organizations world-wide should have robust sustainability strategies in place that move towards net zero and encourage the implementation of robust energy efficiency schemes that reduce energy consumption before considering carbon offsetting protocols as a last resort."[34]

- The lifecycle of hardware in data centres should be discussed to ensure a responsible approach is being taken towards a circular economy. In a circular economy, products are repaired, reused or repurposed as priority, with recycling as a last resort. This helps to protect depleting natural resources required in the manufacture of technical hardware but it also

[33] Figure 25, *Carbon impact of video streaming* (2021). Available at: https://www.carbontrust.com/resources/carbon-impact-of-video-streaming.
[34] ITU-R (2022) *Advice for sustainability strategies incorporating carbon offsetting policies*. Available at: https://view.officeapps.live.com/op/view.aspx?src=https%3A%2F%2Fwww.itu.int%2Fdms_pub%2Fitu-r%2Fopb%2Fop%2FR-OP-R.104-2022-MSW-E.docx&wdOrigin=BROWSELINK.

reduces e-waste. With the UN stating that only 20% e-waste is recycled[35], a pro-active approach is essential.

The European Broadcasting Union (EBU) has published a document which may further support SMPTE members in their conversation with cloud providers. The report states: "It is not enough to state that having shipped our Cloud Services to a third party, it is not therefore 'our problem'."[36] The emissions resulting from the supply chain of a business fall into their Scope 3 carbon footprint. Scope 3 typically accounts for over 70% of a company carbon footprint[37], so outsourcing needs to be carefully managed from a sustainability point of view. The EBU provides a very useful set of guidelines for procuring sustainable cloud services. These guidelines can be found in the EBU Recommendation: 'Sustainability Requirements for Procurement of Cloud Services'. [38]

LIMITATIONS AND RECOMMENDATIONS

The Working Group recommend that further work would be most beneficial in the following areas:

DATA AVAILABILITY AND BOUNDARY TRANSPARENCY

Little data is available on the actual efficiency of a server rack running in the cloud. Whilst the PUE of cloud is better than most on-premise operations[39], there is limited information on what really happens inside a data centre, including percentage load on hardware in idle or operating mode, server types and consumption statistics. We understand that it can be difficult to obtain granular level detail from a multi-tenanted cloud eco-system, but more detailed data would greatly assist customers in making sustainable choices. DIMPACT in their recent Methodology statement found the same issue with data availability from cloud vendors:

"Currently, we have seen that data from providers may not include both location-based and market-based emissions or may be aggregated to include carbon offsetting. In addition, these may or may not include data on their own Scope 3 emissions. Many of these discrepancies may be explained by the fact that there is no cross-industry standard that is available to these vendors for such reporting."[40]

[35] *UN report: Time to seize opportunity, tackle challenge of e-waste* (2019). Available at: https://www.unep.org/news-and-stories/press-release/un-report-time-seize-opportunity-tackle-challenge-e-waste.

[36] EBU (2022) *SUSTAINABILITY REQUIREMENTS FOR PROCUREMENT OF CLOUD SERVICES*, *https://tech.ebu.ch/docs/r/r170.pdf*.

[37] *Scope 3 Emissions* (2022). Available at: https://www.unglobalcompact.org.uk/scope-3-emissions/.

[38] EBU (2022) SUSTAINABILITY REQUIREMENTS FOR PROCUREMENT OF CLOUD SERVICES Available at: https://tech.ebu.ch/docs/r/r170.pdf

[39] Carrero, L. (2022) *How do data centers improve energy efficiency?* Available at: https://www.stackscale.com/blog/energy-efficiency-measures-data-centers/.

[40] Methodology Statement DIMPACT.pdf

DIMPACT has a strong base of participants, advisors, and researchers, and have stated that they will: *"...continue to work with cloud service providers to understand their calculation and attribution methodologies and encourage standardisation in their GHG reporting to customers."*

Meanwhile, in the absence of detailed data, customers would be advised to a) collaborate with cloud providers on what information *is* available and understand the roadmap for getting more, b) utilise assumptions-based models such as the Cloud Carbon Footprint[41] EC2 carbon calculator to gain an estimate of energy consumption from this aspect of cloud computing, c) explore hardware and software solutions on the market which track energy usage in a rack such as Power Distribution Units with integrated energy measurements, and d) use data points from reputable sources to make assessments e.g. the IEA[42] publishes average energy consumption per GB of data transferred.
Monitoring electricity usage is more pertinent than ever in the current energy crisis. Soaring energy prices will inevitably start influencing buying decisions which may bring repercussions in how we utilise cloud services, both in terms of more conscious shifting from on-premise to remote data centres and a focusing of minds on issues such as content storage and archiving.

REPORTING STANDARDS

The lack of a common framework is a broader challenge across global sustainability reporting. For our industry specifically, it would be a huge step forward to have a suite of standards to measure the environmental impact of digital content processing *across the workflow*. Increased transparency and availability of data along with reporting methods would inevitably give business leaders greater confidence in making sustainable choices and propel us forwards as an industry in our ability to effect change.

Carbon calculators aimed at content production include Albert[43], ECOPROD[44] Carbon Clap and KlimAktiv[45] and the Green Production Guide Calculator tool - PEAR[46] . These tools exist to support more sustainable production practices and are vitally important tools supporting production teams globally in their green efforts.

DIMPACT[47], through the Responsible Media Forum, and the Greening of Streaming[48] have been spearheading work into measuring the carbon impact of content streaming.

We are optimistic about the work that the Greening of Streaming[49] are doing to unify standards for measuring carbon impact across the audio-visual industry. Furthermore, the European Union through its Media and Audio-Visual Action Plan has committed to working towards the development of a unified methodology of CO2 emissions, with Albert, Ecoprod, and Workflowers all endorsing and supporting this

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[41] *Cloud Carbon Footprint - An open source tool to measure and analyze cloud carbon emissions* (no date). Available at: https://www.cloudcarbonfootprint.org.
[42] *IEA – International Energy Agency* (no date). Available at: https://www.iea.org.
[43] *Home* (2022). Available at: https://wearealbert.org.
[44] Utilisateur, S. (no date) *Home*. Available at: https://www.ecoprod.com/en/.
[45] gGmbH, klimAktiv (no date) *Greenshooting CO2-Rechner*. Available at: https://mfg.greenshooting.de/de_DE/.
[46] Green Production Guide (2022) *Toolkit | Green Production Guide*. Available at: https://www.greenproductionguide.com/tools/.
[47] *DIMPACT - Responsible Media Forum* (no date). Available at: https://responsiblemediaforum.org/dimpact.
[48] *Home | www.GreeningofStreaming.org (no date). Available at: https://www.greeningofstreaming.org.*
[49] *Home | www.GreeningofStreaming.org (no date). Available at: https://www.greeningofstreaming.org.*

initiative. On a broader global scale, the Entertainment Net Zero Accord (ENZA) aims to bring together global stakeholders in film and television to develop industry guidelines and an agreement to implement climate solutions.

In the US where carbon emission disclosures are not currently regulated, there has been a move towards the reporting of non-financial data from the US Securities and Exchange Commission (SEC) which we welcome. In March 2022, the SEC opened a public consultation to a proposed rule change[50] that would require public companies to include sustainability disclosures as part of their regular financial reporting requirements. This measure is designed to assist investor decision-making as ESG indices are widely known to lack standards. At the time of writing, it is not clear if and when this rule change will take effect.

END TO END IMPACT

The Working Group observe that there is a good understanding and support structure for environmental management in content production and a good base of knowledge on the carbon impact of content streaming.

However, the areas of post-production, content versioning, localisation, and broader distribution methods beyond streaming, appear to be less well served in terms of carbon accounting.

The DPP Committed to Sustainability Programme provides companies across the supply chain with a best practice toolset and accreditation for sustainability practices. Yet the Working Group feel that further gains would come from closer collaboration between the existing support groups and resources to provide an industry-wide end to end carbon impact assessment framework. The goal being to gain greater visibility on the carbon impact of each part of the supply chain using the same start and end points for each component part. The Working Group recommends that metadata is considered as a vehicle to track emissions at each stage of the process so that carbon impact is recorded and visible alongside other content identifiers.

END USER STATISTICS

With the volume of IPTV and on-demand content increasing, and home devices being some of the biggest carbon contributors in distribution, the behaviours of audiences watching this content is highly relevant to businesses working on carbon reduction. Increased transparency of viewer statistics in different regions would greatly assist here.

MANUFACTURING IMPACT

The AWS EC2 assessment explored embodied carbon of servers at a high level, the most notable finding, in the Working Group's opinion, being that emissions in hardware do not appear to correlate to weight, suggesting that the semiconductors are the biggest contributors to CO2e.

Furthermore, we should consider not just the carbon KPI of an operation but the broader environmental impacts from utilising technology, including embodied emissions in hardware, the manufacturing process, raw materials used, shipping and end of life treatment. A Life Cycle Assessment (LCA) is commonly used by

[50] Crenshaw, C. (2022) *Statement on the Enhancement and Standardization of Climate-Related Disclosures for Investors*. Available at: https://www.sec.gov/news/statement/crenshaw-climate-statement-032122.

eco-experts to assess this end-to-end impact, but caution should be taken when using LCAs to compare products as the scope of each LCA can differ. With reference to cloud sustainability, customers should open this conversation with cloud providers to satisfy themselves that the wider environmental impacts of the technology are being addressed.

CLOSING REMARKS

As noted in the introduction, this paper covers a selection of important case studies. The objective was to initiate discussion in quarters where it has not gained pace already and equip SMPTE members with a foundational knowledge enabling them to have more informed conversations within their business and with industry colleagues. The goal being that sustainability becomes an integral part of any business decision making.

The Working Group acknowledges other areas of the audio-visual industry utilising cloud and not covered by this paper, for instance, virtual production stages which are a rapidly progressing technology. This would be an interesting focus for future study. The Working Group were interested in the results of two studies on the environmental impact of virtual production and recommend these as a good starting point to learn more.

- Sony Pictures analysis of the greenhouse gas emissions from a scene of content shot on-location compared to a scene shot in a virtual production studio.[51]
- Film Paris Region study into Virtual production and its environmental impact. Results due to be shared in November 2022.[52]

There is more work to do, but with the pace of climate change not slowing, there is a need to act quickly and not wait until the perfect combination of data, methodology, standards, and intent are in place.

What this paper clearly tells us, is that companies looking to prioritise resources towards the biggest gains from a sustainability perspective, should begin by looking upstream at production processes, downstream to user viewing behaviour and work with manufacturers to improve the power consumption of increasingly sophisticated hardware in the future.

The cloud must also be actively managed to maximise efficiency, which is already standard practice for many technology teams. From an environmental perspective the cloud has been shown to bring efficiencies. However, comparing energy output of a specific workflow or data package using the cloud versus an on-premise environment can be a challenge due to limited granularity of data and the fact that renewable purchasing is usually factored into a cloud customer carbon footprint reports. Furthermore, there is no standardisation in the boundaries set for carbon accounting in data centres, making comparison harder if your start and end points are not clearly and commonly defined. Data transparency

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[51] Sony Pictures (2022) Sony Pictures_Virtual Production GHG Analysis_2022_2.pdf (sonypicturesgreenerworld.com) Available at: https://sonypicturesgreenerworld.com/sites/sonypicturesgreenerworld.com/files/2022-09/Sony%20Pictures_Virtual%20Production%20GHG%20Analysis_2022_2.pdf

[52] Film Paris Region (2022) *LinkedIn Post* Available at: https://www.linkedin.com/posts/filmparisregion_virtualproduction-cinema-environmentalimpact-activity-6995334653893050368-fC8T?utm_source=share&utm_medium=member_desktop

and visibility of the holistic environmental impacts of products and services is vitally important if our industry is to make meaningful strides in sustainable procurement.

The human aspect of transitioning to the cloud is something this paper has touched on briefly but is a vital consideration in the broader context of sustainability. By adopting cloud workflows, teams may be expected to work in new ways, learn new technology and sometimes leave their tried and tested ways behind. This comes with risk, angst and excitement, companies must think about the impact of cloud transition on their people to ensure proper training, development and support is in place.

The ITV and Microsoft Technical paper cites 'momentum and appetite for experimentation' in 2020 resulting from the pandemic as a trigger for instigating new ways of working because of necessity. They suggest that the industry would be well served in furthering sustainability goals by retaining this open mindedness towards doing things differently. The SMPTE Sustainability Working Group couldn't agree more.

ANNEX: GLOSSARY OF SUSTAINABILITY TERMS[53]

100% renewable electricity: Using 100% renewable sources to support electricity needs.

100% renewable energy: Using 100% renewal sources to support all energy needs, including electricity and fuels.

Alternative energy: Substitutes for fossil fuels and petroleum liquids, i.e. ethanol, biodiesel, and tar sands substitute energies. Alternatives for generation and storing electrical power are wind, solar, and battery substitute energies.

Biodegradable: (of a substance or object) capable of being decomposed by bacteria or other living organisms and thereby avoiding pollution.

Biodiesel: A renewable fuel for diesel engines derived from natural oils such as soybean oil.

Biomass: Plant or animal materials used to create energy.

Biophilia: A love of life, living, and affinity for living things.

Blackwater: Contaminated wastewater coming from toilets, kitchen sinks, and dishwashers, i.e. with toxins, that must be drained into separate blackwater pipes for extraction, and it cannot be mixed with greywater.

Black carbon: Defined as aerosol, mostly formed by the incomplete combustion of fossil fuels.

Blue carbon: Carbon captured by living organisms in coastal and marine ecosystems, and stored in biomass and sediments.

Blue hydrogen: Hydrogen produced from natural gas where CO2 is captured and sequestered.

Byproduct: Excess material produced.

CO2: Chemical formula for carbon dioxide

[53] Kibo121 (2022) Available at: www.kibo121.io

CO2e: Shorthand for carbon dioxide equivalent. See Greenhouse gases.

Carbon accounting: The process by which organizations quantify their carbon emissions and carbon reductions in order to understand impact and to set goals towards improvements.

Carbon budget: The maximum amount of cumulative net carbon emissions that would result in limiting global warming to a given level.

Carbon calculator: A tool to measure carbon emissions of an activity or product.

Carbon disclosure: The act of voluntarily disclosing the environmental sustainability of a company. See ESG rating services.

Carbon Disclosure Project: CDP is a global environmental impact non-profit, providing a platform for companies, cities, states, and regions to report information on their climate, deforestation, and water security impacts.

Carbon emissions: Pollution released into the atmosphere from carbon dioxide and carbon monoxide; often produced by motor vehicles and the burning of fossil fuels for energy.

Carbon emission sources scope 1: Emissions directly generated at your operations e.g. company owned fuel powered vehicles, diesel powered generators.

Carbon emission sources scope 2: Emissions caused indirectly by consuming electricity. These emissions are generated outside the business by the energy supplier, but the business is indirectly responsible for them.

Carbon emission sources scope 3: Emissions generated up- and down-stream from the business.

Carbon footprint: The amount of carbon equivalent greenhouse gases produced by the business and/or lifestyle.

Carbon neutral: Balancing carbon emitted with purchased carbon credits or offsets. This does not necessarily result in a reduction in emissions from a persons or company activity.

Carbon offsets: Monetary purchase to counter the amount of carbon emitted into the atmosphere rather than reducing carbon use.

Carbon removal, Carbon sequestration: Can be achieved naturally or manufactured. That act of capturing and storing carbon out of the atmosphere.

Circular economy: A system dedicated to eliminating waste by reusing, sharing, repairing, and recycling resources. Use products and services to their fullest. When the product lifecycle is complete, you must repurpose the material into the production phase of something else.

Climate change: Significant change in climate including temperature, precipitation, or wind that lasts for an extended period.

Climate positive: Exceeding achieving carbon neutrality by removing additional carbon dioxide from the atmosphere; also referred to as carbon negative.

Climate resilience: the study of existing systems' capacity to handle stresses and maintain functionality imposed by climate risk.

Closed-loop: A system where everything is recycled and reused, the most sustainable form of production and consumption.

Composting: Controlled decomposition of organic material.

Compression: The process of encoding a video file to reduce its size to consume less space and for easier transmission over a network or the internet.

Conscious capitalism: A free market economy that mutually benefits both people and the environment.

Conservation: Protection from harm.

Consumption footprint: A set of data used to define general consumption for a defined population.

Corporate social responsibility (CSR): The concept of incorporating social causes or contribution into a company's business model and employee culture.

Cradle to cradle: See circular economy

Decarbonization: The process to achieve zero fossil fuel carbon existence.

Deforestation: Conversion of forested lands into non-forest use.

Eco-conscious: The mentality to focus on reducing harm to the environment wherever possible.

Eco-districts: A collaborative planning approach that focuses on regenerative urban development at the neighborhood scale.

Eco-friendly: Environmentally minded actions that cause minimal harm to the earth.

Ecological footprint: Measurement based on the amount of nature it takes to support something. Measures how much natural resources you use in your daily life and how much land your lifestyle requires.

Ecological restoration: The process to artificially restore an ecosystem to its original form, after it's been damaged.

Emissions factor: How much carbon is created per unit of activity.

Emissions reduction roadmap: Defining the magnitude and timing of emissions reductions to reach a target.

Energy efficient: Uses the smallest amount of energy possible to provide power.

Environmental impact: The effect something has on the environment.

Environmental, social, and governance (ESG): a business strategy that encompasses an environmental cause, a social cause, and a self-governing body in leadership that holds the company accountable.

ESG rating services: Organizations that examine a company's environmental, social, and governance policies to determine sustainability. These ratings are used by investors to determine their choice of investments.

Ethical or sustainable investment: An investment strategy in a company that incorporates ESG/CSR principles.

Fair trade: Principles of fair treatment, wages, and safe working conditions for workers.

Freecycle: Exchanging goods to extend their lifecycle and keep reusable items out of landfills.

Geothermal energy: Renewable energy derived from hot water or steam with the earth.

Global warming: The average increase of temperature of the troposphere.

Gray water: Domestic wastewater, without toxic chemicals, including wash water from the bathroom, kitchen, and laundry.

Green: Term used to describe behavior, product, policies, people, etc. that minimize environmental damage.

Green building: Using techniques to build based on ecological principles to maintain a healthy structure that minimizes environmental impacts.

Greenhouse effect: When excessive heat is trapped and built up in the troposphere by a blanket of gases.

Greenhouse gas (GHG): Gas in the atmosphere such as carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, Sulphur hexafluoride, nitrogen trifluoride

Greenhouse Gas Protocol (GHGP): a partnership between the World Resources Institute (WRI) and the Business Council for Sustainable Development (WBCSD). The GHGP provides accounting and reporting standards.

Greenwashing: Misrepresenting something as being "green" when it's not environmentally sound.

Grid decarbonization: Replacing fossil fuel powered energy plants with renewable energy sourced plants.

Green Hydrogen: Hydrogen produced by splitting water into hydrogen and oxygen.

kWh: unit of energy equal to one kilowatt power sustained for one hour. 1000 watts used for one hour. Used to calculate energy consumption to calculate carbon emissions.

Life cycle emissions: The environmental impact of a product or activity throughout its entire life cycle.

Metric ton: The equivalent of 2,204.6 pounds or 1000 kilograms.

Mitigation: Stop climate change from getting worse.

Naked packaging: Products that are sold without packaging.

Natural capital: A value derived from natural resources e.g. an ecosystem, water, wood, mined materials, not human, economic or equipment capital.

Natural resources: Raw materials supplied by nature.

Net-zero: Cutting GHG emissions to as close to zero as possible with any unavoidable residual emissions being offset to reach net zero. True net-zero measurements consider carbon emission sources for Scope 1, 2, *and* 3.

Net-zero water: An approach where a building or community uses only the water that falls on site. Involves limiting the consumption of water resources and then returning it back to the same water source.

Organic: Anything that was once a living organism.

Ozone: The tri-atomic form of oxygen (O3).

Post-consumer: Previously used by consumers before being reprocessed into a new product.

Preservation: To keep something the same and prevent it from being damaged.

Production footprint: The amount of carbon equivalent greenhouse gases resulting from the making of a product.

Rainwater harvesting: Collecting and storing stormwater for later use.

Reclaimed: Waste materials refurbished for new products.

Recycle: To reprocess reusable goods, breaking down the original.

Reduce: To cut back on harmful habits that produce waste.

Reforestation: Planting of forests on lands that were depleted.

Remineralize: To restore mineral content to an environment.

Renewable energy: Electricity from replenishable sources such as geothermal, hydropower, solar, and wind.

Science Based Targets: The greenhouse gas emissions reduction targets that are consistent with the level of decarbonization that is required to keep the global temperature increase within 1.5 – 2 degrees C compared to pre-industrial levels.

Single-use: Items used one time and then discarded.

Social enterprise: A for-profit business whose core business model is tied to a social cause.

Socially responsible investing (SRI): Actively investing in companies or funds that support CSR initiatives.

Solar energy: Energy derived from the sun.

Sustainability: The ability of a system to be maintained at a certain rate or level. It involves creating an ecosystem where people, planet and profit can live in harmony without compromising one or the other. Environmental practices that protect natural resources needed by future generations for a positive quality of life.

Supply chain: The process from initial point of raw material sourcing through to end-user consuming the product.

Tons of CO2: Measurement of carbon emissions per activity.

Triple bottom line: People, Planet, Profit. A business strategy that prioritizes people, planet, and profit equally.

Upcycle: To reprocess reusable goods into something new from its current state.

Value chain emissions - Downstream: Indirect emissions from activities related to delivering your product or service.

Value chain emissions - Upstream: Indirect emissions from purchased goods and services to operate your business.

Value proposition: The consumer value is derived from a product, service, or organization.

Vegan: A diet and lifestyle that avoids all animal-derived products.

Vegetarian: A diet that avoids meat from the diet.

Water scarcity: When all the demands on the water supply cannot be met.

Water security: The ability to provide safe access to adequate quantities and qualities of water for sustaining human well-being, protecting ecosystems, and socio-economic development.

Wind energy: Energy collected through the motion of heavy winds.

Wish-cycling: An aspirational approach to recycling items without knowing if they're recyclable but expecting them to be properly dealt with.

Zero-waste: Avoiding products that create waste to avoid contributing to landfills, incinerators, and waste discarded in nature. Minimal waste is a more realistic term, as it's impossible to create zero waste.

Data for this glossary come from a variety of sources including the UN Climate Change, industry reports, and Wikipedia.

Sustainability in Media

Albert	https://wearealbert.org/
EBU	https://tech.ebu.ch/groups/spsm
IBC	https://www.ibc.org/trends/sustainability-focus-the-call-for-a-sustainable-film-industry/7656.article
DPP	https://www.thedpp.com/sustainability
Greening of Streaming	https://www.greeningofstreaming.org/
EMA Environmental Media Association	https://www.green4ema.org/
Green Film Shooting	https://greenfilmshooting.net/blog/en/
The Green Production Guide	https://www.greenproductionguide.com/
Sustainable Production Forum	https://www.sustainableproductionforum.com/spf21-recap
The Impact of Emerging Sustainability Practices in the Film Industry – AMT Lab @ CMU	https://amt-lab.org/blog/2021/12/what-does-sustainability-look-like-in-the-film-industry
BBC R&D	https://www.bbc.co.uk/rd/blog/2020-09-sustainability-video-energy-streaming-broadcast
Responsible Media Forum	https://www.bbc.co.uk/rd/blog/2020-09-sustainability-video-energy-streaming-broadcast

International Sustainability Framework

UN Framework Convention on Climate Change (UNFCCC): The United Nations Framework Convention on Climate Change (UNFCCC) established an international environmental treaty to combat "dangerous human interference with the climate system", in part by stabilizing greenhouse gas concentrations in the atmosphere.

Nationally Determined Contributions (NDC): NDCs embody efforts by each country to reduce national emissions and adapt to the impacts of climate change. The Paris Agreement (Article 4, paragraph 2) requires each Party to prepare, communicate and maintain successive nationally determined contributions (NDCs) that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions.

UN Sustainable Development Goals (**SDGs**) or **Global Goals** are a collection of 17 interlinked global goals designed to be a "blueprint to achieve a better and more sustainable future for all".

The **Intergovernmental Panel on Climate Change** (**IPCC**) is an intergovernmental body of the United Nations responsible for advancing knowledge on human-induced climate change.

The **Science Based Targets initiative** (**SBTi**) is a collaboration between CDP, the United Nations Global Compact, World Resources Institute (WRI) and the World Wide Fund for Nature (WWF).[1] Since 2015 more than 1,000 companies have joined the initiative to set a science-based climate target.

Greenhouse Gas Protocol: GHG Protocol establishes comprehensive global standardized frameworks to measure and manage greenhouse gas (GHG) emissions from private and public sector operations, value chains and mitigation actions.

The **Kyoto Protocol** was an international treaty which extended the 1992 United Nations Framework Convention on Climate Change (UNFCCC) that commits state parties to reduce greenhouse gas emissions, based on the scientific consensus that (part one) global warming is occurring and (part two) that human-made CO_2 emissions are driving it.

The **Paris Agreement** (French: *Accord de Paris*), often referred to as the **Paris Accords** or the **Paris Climate Accords**, is an international treaty on climate change, adopted in 2015. It covers climate change mitigation, adaptation, and finance.