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Use-of-system approaches for Electricity Footprinting of Digital Media Services
Contents

- Context, Motivation for Environmental Footprinting
- Understanding Environmental Impact of Whole Services
- Motivating energy intensity
- Use-of-System updates
Effects of ICT


Fig. 6. A matrix of ICT effects, based on [67]
NetZero

- ICT carbon emission 2-4% of global
- Carbon Reduction Targets
  - ITU 45% until 2030
  - BT NetZero 2045
Our Work Assessing Digital Media Services

- Video, Games, Web, Metaverse, Crypto, AI, etc
- OTT

- 2011 The Guardian
  - Transition from paper to digital

- 2015 BBC
  - Strategically evaluate move to video on demand

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BBC as an Example
BBC as an Example

Understanding Whole Services
Science Based Targets initiative

- SBTi requires setting organizational targets in line with emissions reductions to keep warming to well below 2.0°C or 1.5°C
- Most Digital service companies will need to report on energy and carbon “end-to-end”
Environmental Reporting for Digital Services

- Major UK TV channels
- Publishers
- Ad Networks
- ISP
- Online tool
- Modules
- Corporate reporting and strategy
- Community working groups
Understanding How Services are Used
Video Streaming

The Carbon Trust: Carbon impact of video streaming
2021:
Effect of Electricity Carbon Intensity

Figure 19. Emissions from video streaming by region in 2020
Effect of Choice of User Device

The image shows a bar chart comparing the gCO₂e/hour of different devices. The devices are categorized as follows:

- 50" Smart TV | FHD (1080p)
- iPhone | Cellular network | Automatic data setting
- Laptop | SD (480p)
- Average mix

The chart indicates that the 50" Smart TV has the highest gCO₂e/hour, followed by the iPhone, then the Laptop, and the Average mix has the lowest gCO₂e/hour.

- Viewing device
- Home router
- Data centres
- TV peripheral
- Network transmission

The website mentioned is bristol.ac.uk.
Interaction Design
Reducing Digital Waste

Annual Total Energy Consumption (2016)

- YouTube Servers
- Core Network
- Access Network
- User Devices
- Cellular Networks

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YouTube as an Example

YouTube Delivery System
Conservative Estimate of Carbon Emissions of YouTube distribution 2016

Electricity: 19.5 TWh, Carbon emissions: 10.0 MtCO$_2$e

(We assume all Google Data Centres and Global Cache use renewable energy.)

<table>
<thead>
<tr>
<th>Share of Music Audio Only</th>
<th>Emissions Reductions (KtCO$_2$e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10%</td>
<td>117</td>
</tr>
<tr>
<td>25%</td>
<td>293</td>
</tr>
<tr>
<td>50%</td>
<td>586</td>
</tr>
</tbody>
</table>

ELIMINATING VIDEO DIGITAL WASTE
Use-of-System Energy Intensity Metrics
their monthly carbon footprint would be 9.4 kg CO2e. Simply turning off the video, however, would reduce the monthly emissions to 377 g CO2e.”

DOI: 10.1016/j.resconrec.2020.105389
\[ E = P_b \cdot t + \nu \cdot I_d \]

Dynamic Power Model

Malmodin 2020
Figure 1: Reinforcing feedback stimulating Infrastructure Growth


8) Cloud Computing Emissions Comparison, Nucleus Research, 2010
A CHANGE-ORIENTED INTENSITY METRIC

- IAB ’22, Dec 05–07, 2022, Online
- burden data traffic at peak time with proportionally higher share of the baseline power consumption than traffic at other times
- scales the data volume in each 30-minute time window inverse proportionally to peak traffic

\[
C_i = \frac{\left( \frac{V_i}{V_P} \right) \cdot V_i}{\sum_{i=1}^{48} \left[ \left( \frac{V_i}{V_P} \right) \cdot V_i \right]}
\]

\[
E'_{bi} = E_{bi} \cdot C_i
\]

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Energy Intensity
Carbon Intensity

![Graph showing Carbon Intensity with different intensity models: Basic Mean, Transformed, and Electricity Carbon Intensity.](bristol.ac.uk)
Future Work

- Evaluate specific services
- Apply to Data Centres
- Combine with Malmodin 2020

\[ E_i = I_{b_i}' \cdot v_i + v_i \cdot I^d_v \]
Thank you