Measuring the Impacts of Digital Initiatives: Are We Helping or Harming?

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Abstract
Digital technologies are a ubiquitous and fundamental part of our modern lives. While there is an increasing push for digitization across all sectors — healthcare, education, finance, agriculture — this new and accelerating wave of digital innovation is also increasing the energy demands on an already overextended planet. Every byte is nothing more than energy, and energy has a carbon cost.

As we speak, climate change is disproportionately affecting women, children, those living with disabilities, BIPOC communities, and those experiencing poverty and homelessness. We have an ethical obligation to ensure that our efforts to help aren't causing undue harm.

We need to measure the impact of our digital initiatives to understand the net value of our efforts. These easy-to-use metrics allow us look at the total impact of the digital tools that we use to disseminate information and facilitate cooperation in SDG initiatives.

Keywords
digitization, sustainable content, ESG, climate change, energy, GHG

Introduction
The U.N. Sustainable Development Goals (SDGs) can be accelerated with information and communication technologies (ICT).[1] A visit to any sustainability-themed conference will reveal everything from artificial intelligence (AI) and the internet of things (IoT) to a steady stream of websites, apps, videos, and podcasts. It doesn't matter if the problem is poverty, education, recycling, or climate. The presented solutions are always digital. We're going to tech our way out of this mess!

For those of us who came of age alongside the Internet, digital was presented as the ultimate in innovation and progress. It was going to be a shiny, paperless, sci-fi utopia. After all, digital was free and clean and harmless, right?

Not exactly.

Our digital content is just bits and bytes of data. Data is nothing more than energy. And energy—at least for the foreseeable future—has a carbon footprint. Direct connections can be made between every web page, email campaign, app, or video, and the corresponding carbon emissions. By throwing more tech at the problem, we're creating an even bigger problem. This new and accelerating wave of digital innovation is increasing the energy demands on an already overextended planet, the effects of which are already being felt by marginalized populations and underrepresented communities.

Methods and Materials

If we know that digital content is just energy, and that energy has a carbon footprint, then surely it would be easy to measure the kilowatt hours (kWh) per gigabyte of data transferred. In reality, this is surprisingly complicated.

The research results vary widely. There are many sources that measure digital impacts in the aggregate, globally or regionally. For example, Freitag estimates that ICTs represent between 2.1% and 3.9% of annual greenhouse gas (GHG) emissions.[2] This is similar to the annual impact of the aviation industry at 2.4%[3] Regional studies also provide aggregate data; information and communication technology (ICT) represents between 25%–33% of the electricity consumption of European households.[4] There is also much talk of the overall impact of data centers in terms of overall energy use—impacts of servers, storage, and cooling.[5,6,7] But the true impact of digital content doesn't come from data sitting there. Just like the boxes stored in your attic, the significant energy impact occurs when you move them.

An average sized web page weighs 4 MB. It's using relatively little energy on your server. But if you download that information to your phone, your tablet, and your laptop, you have moved 4 MB of data three times. That one web page accounts for 12 MB of data transferred. Three times the energy, and three times the emissions. But we want our data to be accessed hundreds, thousands, even millions of times. Every download multiplies the energy and emissions of your website, app, video, podcast, image, or other form of digital content.

Complexity of measurement

How can we measure the energy use and corresponding emissions of our data? How many kilowatt hours of energy do we need to transfer one gigabyte of data? The answer is surprisingly complex. Answers vary from "a lot" to "not much" to "it depends how you measure it." All sources agree on one thing: it's complicated, and the scientific community hasn't yet come up with a broad consensus on measuring emissions from digital products and services.

Why? Because the process of measuring emissions from data is a game of averages.

- Most of the world is using energy that is at least partially generated by fossil fuels. Fossil fuels generate carbon emissions. Even if our data center or organization is located someplace that uses majority renewable energy, our users are not. Those who access our webpages, videos, apps, and podcasts can be located anywhere. Therefore, we need to make some global estimates and come up with an average for the emissions generated.
- Different devices and applications draw energy differently. We need to establish an average.
- Emissions vary based on the intensity of the draw on the energy grid at any given time of day. Again, we need to establish an average.

There is limited research into the impact of moving data. Delucchi and Jacobsen[8] estimate 5.12 kilowatt hours (kWh) of energy for each gigabyte (GB) of energy transferred. This data, while valid at the time of publication, does not account for progressive improvements in infrastructure efficiency in the intervening decade, estimated to double in efficiency every 18 months.[9] Greenwood[10] suggested a current estimate of less than 1 kWh/GB of data that accounts for IP core networks and access networks (included in most calculations), plus cables and data centers, as well as the networking equipment and devices in your home or office. This number that is continuously revised on his website (SustainableWebDesign.org) as overall efficiency improves.

However, we should be aware that there are studies and data that can reinforce almost any agenda, higher or lower. While you may be confronted with different and conflicting mathematical assumptions, know that the underlying principles are sound:

- Data = energy
- Energy = emissions
- Therefore, data has an emissions impact

Accelerating consumption offsets gains in renewable energy

It's an oft-quoted statistic that 90 percent of the world's data has been created in the last two years. I traced that information back to research by independent research organization SINTEF, reported in *Science Daily* in 2013.[11] (SINTEF, 2013) With the rise of social media, we are all content creators and consumers, generating data and using energy at an unprecedented rate.

Qualitative studies in the Netherlands and Denmark by Christensen and Rommes[12] (2019) note that "energy-intensive use of ICT is encouraged through mutually reinforcing social norms, social-institutional embeddedness and scripts regarding their everyday practices. In addition to a lack of awareness of the environmental impact of ICT, this explains why young people in general find it hard to imagine using ICT less to save energy."

Global internet traffic surged more than 40 percent in 2020, the first year of the pandemic.[13] But as we've returned to some amount of normalcy, our internet-intensive habits remain ingrained. Our digital footprints are ever-increasing, and every byte has a carbon cost. While we are increasing our renewable energy generation, it is not meeting our increased demand.

According to Our World in Data,[14] we have nearly doubled our energy consumption in the past four decades. As we see in Figure 1, our consumption jumped from 87,599 terawatt hours in 1980 to 174,285 terawatt hours in 2019. The comparison is made using data from 2019, the last pre-pandemic year. While there was a slight downturn in energy consumption in 2020 due to pandemic shutdowns, the trend towards increased energy consumption resumed in 2021. So, as we're increasing our percentage of renewable energy, our increased overall consumption limits the amount of headway that we're making on a true green energy transition.[14] Digitization is driving a significant amount of that consumption.

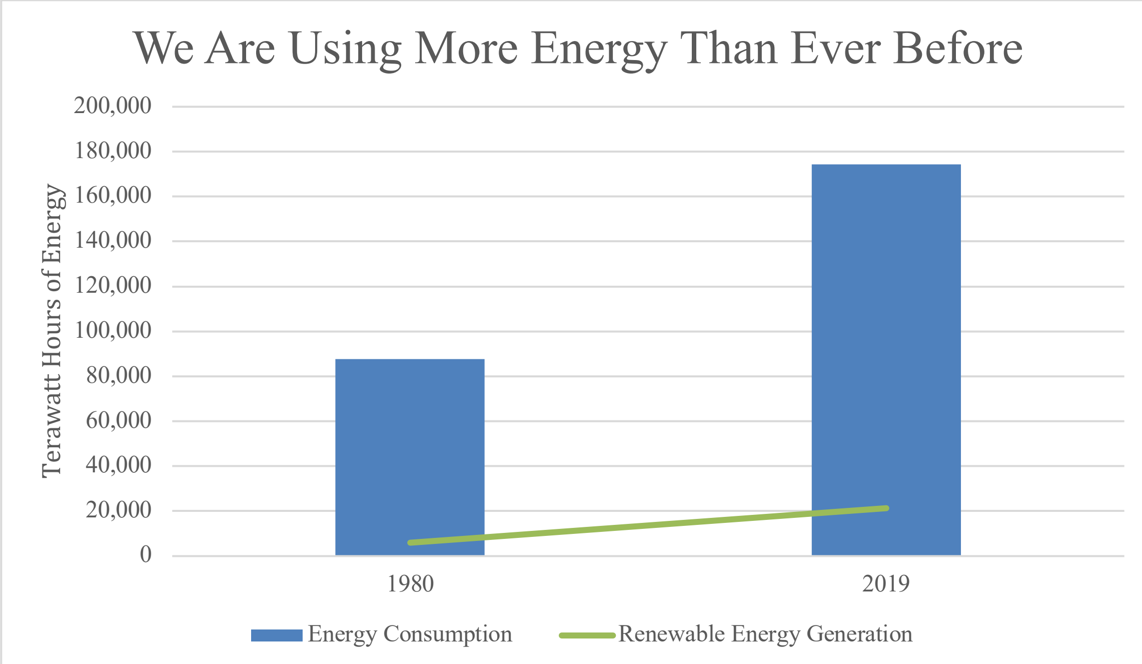

Figure 1 The world is using more energy than ever before. While renewable energy production is increasing, it's not keeping pace with our growing demand. Source: Our World in Data.

It is impractical to suggest that the world stop creating or consuming digital content. We can use less energy, and use it more efficiently, to accelerate that conversion and reduce the greenhouse gas emissions from fossil fuels during the transitional period. Given that the goal of content is consumption, it's important to create the most efficient content possible to meet the audience needs.

Findings

For any digital content initiative, if we know the amount of data and the number of times that the data is transferred, we can calculate the energy and emissions impact of every project. I have used the estimates from Greenwood and other resources to show how we can balance the value of content for the audience while minimizing the impact to the planet. A tutorial walking through the process of measuring impact was first published in *Technical Communication* in 2023.[15] But we shouldn't create any digital project, large or small, without an effective understanding of what our audience needs.

The right content in the right place

Different content has different purposes. Just as a novel is not the same as a biography, a website is not the same as a podcast. We must begin with our audience. What does our audience need to achieve their goals? In most cases, we default to websites as our primary method of digital communication. They are relatively simple to create and maintain. They are also hard to do well.

In her book, *Strategic Writing for UX*, Torrey Podmajersky says, "The writer needs to identify the goals of the person who will use the experience as well as the goals of the organization making the experience."[16] Plain language improves readability and clarity for audiences of all levels, explains Sarah Richards in *Content Design*.[17]

"Clear communication in plain language starts with a clear understanding of the audience and respect for the audience's needs for information," says Russell Willerton in *Plain Language and Ethical Action*.[18] Christopher Balmford, an expert in making legal language clear, says that plain language is not simply about the choice of words and sentences, but rather the whole document, including language, structure, and design.[19,20] The Plain Writing Act of 2010 takes a words-only approach to plain language: "Writing that is clear, concise, well-organized, and follows other best practices appropriate to the subject or field and intended audience."[21] It comes with empathy for the reader. It supports comprehension; typically uses fewer words; improves accessibility; and improves translation and localization. Google's key values state it simply: "Focus on the user and all else will follow."[22]

When we create digital content thoughtfully and responsibly, we are creating sustainable content that minimizes its planetary impact.

Leveraging our efforts at work: Influencing large-scale digital initiatives

What has more impact: personal choices, or our influence at work? When it comes to digital initiatives, our work has vastly more impact than our individual choice. For decades we've heard about our climate or carbon footprint: the impact that our lives and choices have on the Earth's climate. This is a result of a very effective BP marketing campaign to place the perceived weight of climate change on the shoulders of individuals, shifting the focus from the fact that BP is one of the top 15 polluters in planetary history.[23]

Individuals are not the largest contributors to climate change. Even if every human implements personal behavioral changes where we can, the IEA notes that it still only reduces greenhouse gas emissions by about 4 percent by 2050.[24]

A 2017 report published by CDP, the not-for-profit organization that runs the global disclosure system, 100 companies are responsible for more than half of all greenhouse gas emissions since the start of the industrial revolution 250 years ago. These organizations are responsible for 71% of all emissions since 1998.[25] If most emissions are driven by corporations, then it makes sense that we have the most opportunity for leveraging our impact at work: the source of the most energy-intensive digital content.

Reducing the digital Footprint improves Scope 3 emissions

Organizations are increasingly looking to reduce their carbon footprints and demonstrate sustainable operations. There are three "scopes" of emissions that are commonly tracked.

- Scope 1: Direct emissions generated by an organization's facilities or vehicles.
- Scope 2: Indirect emissions from the electricity, heating, steam, or cooling purchased by an organization.
- Scope 3: Everything else. This includes upstream impacts from purchased goods and services in the supply chain; it also includes downstream emissions and waste from distribution, processing, and even the use of content.

When organizations thoughtfully create and manage their digital content, they have a direct impact on Scope 3 emissions.

Improving Websites Reduces Carbon Footprints and Improves User Experiences

One of the most straightforward ways to reduce an organization's digital carbon footprint is by improving its website, the most universal form of digital content. Many sites are bloated with legacy pages that have never been deleted, as well as being packed with imagery and backend scripts that increase the weight of each individual page.

Akamai, a technology and cybersecurity company, has established the standard for download times and visitor patience. In 2009, in a study conducted with Forrester Consulting, they declared that consumers expect web pages to load in two seconds and will abandon a site after three seconds.[26] Ten years later, in a 2019 white paper on retail best practices, Akamai talked about how customers will abandon your site if pages load slowly. Lighter-weight pages load faster. "Faster pages mean a better user experience,' the paper notes. "That translates into better conversion rates—and better profitability."[27] We can simultaneously improve the user experience and improve business outcomes with leaner, more sustainable content.

Content calculator: Metrics for measuring the impact of digital initiatives

To measure the impact of any digital initiative, you need to know just a few basic bits of information:

1. The size (or "weight") of what we're measuring
2. The number of hits/downloads/clicks
3. The kWh/GB of data transferred (we're using 0.81 kWh/GB to align with the WebsiteCarbon.com calculator from Tom Greenwood)[28]
4. Access to the EPA Greenhouse Gas Equivalencies Calculator, available online[29]

Comparative Impacts of Digital Media					
	Single Web Page (Average)	App Size (Average Android/iOS Major Social Media App)[30]	Email Blast: Streaming Provider Subscriber Email (Weekly)	Video: 30 Minutes at YouTube HD Quality[31]	Audio: 30 Minutes at Podcast Quality[32]
Size	4 MB	87.12 MB	.075 MB	1,730 MB	23 MB
Hits/ Year	1,000,000	2,000,000,000	200,000,000	10,000	10,000
Subtotal	4,000,000 MB	174,240,000,000 MB	150,000,000 MB	17,300,000 MB	23,000 MB
Convert to GB	4,000 GB	174,240,000 GB	15,000 GB	17,300 GB	23 GB
X 0.81 kWh/GB	3,240 kWh	141,134,400 kWh	12,150 kWh	14,013 kWh	18.63 kWh
Total Emissions	1.4 metric tons CO_2e	61,054 metric tons CO_2e	5.3 metric tons CO_2e	6.1 metric tons CO_2e	0.008 metric tons CO_2e

Figure 2 Calculating the impact of different methods of communication. The calculations use the average weight for a web page, the average weight for a popular image-based social media app (app size only, not emissions from use), and the 75 KB average weight for an email multiplied by subscribers for a streaming provider. Note the difference in impact for the same length video and audio.

Conclusion and Recommendations

Obviously, data and communication technologies play a significant role in our modern lives. We need to be responsible in our solution development, content strategy, and content design to ensure that we're developing resources that help more than they harm.

But we can't afford to ignore the impacts of digitization. We're using more energy than ever before.[33] That energy has a carbon emissions cost, which is driving climate change.[34] These impacts are disproportionately affecting vulnerable populations, including women[35,36] those experiencing poverty;[37,38] and black, indigenous, and people of color (BIPOC).[39] Knowing that the majority of emissions come from corporations and not individuals, it makes sense that we leverage our influence on our organizations to have the greatest impact on the health and wellbeing of others.[40]

The 2022 IPCC Summary for Policymakers notes that "near-term actions that limit global warming to close to 1.5°C would substantially reduce projected losses and damages related to climate change in human systems and ecosystems."[41] When we develop sustainable content, we improve the user experience (UX) and comprehension while reducing our organization's Scope 3 emissions.

By employing the sustainable content calculator, we can measure the direct impact of our digital content. All sustainability entrepreneurs and content creators should keep these numbers in mind when deciding what needs to be communicated, balancing audience needs with the most climate-friendly methodologies for presentation.

There is ample room for additional research into the measurement of energy transfer of data, particularly research that keeps pace with the evolving efficiencies in digital infrastructure and sustainable energy. Given that digital content can be accessed at any time from anywhere, this research needs to establish meaningful global averages. In lieu of that information, we still have an awareness and obligation to reduce the energy and emissions of our digital initiatives to mitigate the impacts of climate change, particularly the more immediate and devastating effects already being felt by marginalized populations in underrepresented communities.

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