

An edited version of this article appeared in the London Review of Books, 19 January 2023: <https://www.lrb.co.uk/the-paper/v45/n02/donald-mackenzie/short-cuts>

I've added at the end a little note on the main sources used e.g. to estimate the average size of puff associated with a single ad 'impression' (i.e. the showing of one ad to one user).

Short cuts: A puff of carbon dioxide

Donald MacKenzie

Dozens, hundreds, perhaps even thousands of online ads can flash before your eyes every day, probably so many that you don't even notice most of them. Generating the electricity to get just one ad to appear on your screen often produces a puff of carbon dioxide sufficiently big that, if it was cigarette smoke, you would see it. Showing a single digital ad to a single user involves, on average, emitting between a fifth of a cup and a couple of cups (of the size used in American recipes) of carbon dioxide. And the digital ad business puffs on quite a scale. No-one knows exactly how many ads are shown online across the world, but informed estimates collected by the researcher Mikko Kotila suggest as many as 400 billion a day.

Using your laptop, phone or connected TV feels very different from taking a flight. Whenever I do that, I have the queasy knowledge that I'm adding significantly to my carbon footprint. That's harder to keep in mind when I watch streaming video, transfer large files or store my photos in the 'cloud', a misleadingly ethereal metaphor for huge datacentres packed with energy-consuming computer servers. The carbon emissions involved in information and communication technologies are difficult to measure, but are probably around 2-3 percent of total global emissions, and perhaps as much as 4 percent. That's comparable in size to aviation's contribution to climate change.

Online advertising accounts for around a tenth of ICT's energy consumption, according to estimates in a 2018 article in the *Environmental Impact Assessment Review* by Matti Pärssinen, Mikko Kotila and colleagues. The screens on which ads appear are of course on anyway (although I've heard of connected TVs 'showing' ads when the screens are switched off). But transmitting the electronic files that generate on-screen ads consumes additional electricity, especially when ads involve video and/or elaborate graphics and animations. Rendering sophisticated ads of this kind on-screen is also energy-intensive. The files containing ads generally arrive separately from the content that you want to interact with or view – perhaps a second or two later. So, for example, your phone may be kept for longer in the high-energy state in which there is a dedicated radio channel open between it and a mobile phone mast.

Digital advertising firms also embed tracking code in websites and in the software packages they provide to developers of mobile apps and games, which means yet

more energy-consuming to-and-fro between your device and external datacentres. And further to-and-fro can be triggered by each and every individual opportunity to show you an ad. If you are using a mobile app, the opportunity will often be offered first to one advertiser, but if they won't pay for it then another advertiser, and another, and another. If you are browsing the web, using Facebook, or searching on Google for something of commercial interest, the resultant opportunities to show you ads are electronically auctioned in real time, with algorithms acting on behalf of different advertisers all able to submit bids to show you an ad in around a second's time. Publishers unhappy with Google's centralised way of organising this bidding have adopted decentralised auctions. These can increase their revenues, but having multiple auctions going on simultaneously means more computing and more electronic messaging, and thus demands more electricity.¹ The advertising-technology entrepreneur Brian O'Kelley tells me that sometimes a single opportunity to show one ad can trigger as many as a thousand auctions.

Many large advertisers are keen to trumpet their commitment to sustainability and the carbon neutrality of their products. Emitting lots of carbon dioxide while doing so is a pretty obvious contradiction, and advertisers' awareness of that has surged in the past year or so. One response can be to keep puffing away and buy an equivalent amount of carbon credits generated by emissions-reduction projects elsewhere, usually in the Global South. But directly cutting advertising's emissions must be a better path. There's a lot of scope for doing that: research by O'Kelley's carbon-measurement firm Scope3 and consultancy Ebiquity suggests that the carbon footprint of ads varies wildly, sometimes nearly 100-fold.

A good way of starting to reduce emissions would be to cut out waste. Many ads (nobody knows quite how many) are never seen by human beings. Sometimes that's because of fraud, with advertisers being duped into paying to show ads on websites without human viewers but with computerised bots clicking away. But there is plenty of waste even in the absence of fraud. Ads, for instance, can be transmitted to the user's device but placed 'below the fold' (on a section of a page that is never seen unless the user scrolls down), or are in view for only a tiny fraction of a second as the user scrolls.

Those who work in digital advertising are fully aware of such issues, and the sector has created an extensive technical apparatus to detect fraud, measure the viewability of ads, and monitor the content alongside which ads will appear, stopping them being shown if that content is judged controversial, upsetting or offensive. An advertiser can, however, still easily waste money and burn a lot of unnecessary carbon even when employing this apparatus. Many 'free' mobile games, for example, make their users do things such as view a video ad or navigate to an external ad-bearing website before being able to move to the next level. No fraud is involved, but having ads forced on you in ways such as this is unlikely to make you enthusiastic about the companies or products being advertised.

¹ Donald MacKenzie wrote about how the apparatuses of online advertising affect news publishers' revenues in the *LRB* of 12 May 2022.

Another form of waste is showing ads on ‘made-for-advertising’ sites. Those sites host lots of trackers and often sell every single ad slot via multiple auctions. Their sketchy content (sometimes recycled or AI-generated) doesn’t usually trigger monitoring systems, and the sites can look good on advertising metrics: clicks are generated, ads are fully viewable, video ads are played right to the end, and so on. But ‘it’s just clickbait,’ says Ruben Schreurs of Ebiquity: “‘You won’t believe how much weight these five celebrities have gained.’” And then the person clicks on that and ... goes to a page which isn’t about that at all, or it’s a fully loaded page with ads, and you have to click refresh so many times to get to some type of content’ – all with minimal benefit to the advertiser. As much as 10-15 percent of what’s spent on ‘programmatically advertising’ (automated real-time ad-buying in marketplaces in which multiple buyers and sellers compete) is wasted on ads on such sites, reports Ebiquity.

Eliminating misspending of this sort would help, but there’s also need to reconsider the processes at the heart of digital advertising, such as the way ads are bought and sold. No-one did more to create today’s real-time market mechanisms than O’Kelley, but he is now deeply ambivalent about some of their effects: ‘I’m not sure it was for the good that we did this,’ he told me. These mechanisms have often sucked advertising revenue from serious news publishers to low-quality outlets, and the multiple auctions involved in decentralised buying and selling increase carbon-intensity.

In order to cut emissions, must we therefore return to centralised ad auctions, probably run by Google (which does make serious efforts to power its datacentres with electricity from renewable sources)? That would be an unpalatable conclusion to many in advertising, who argue that it is unhealthy to have a market dominated by a single big player. A different route would be for advertisers to focus their advertising better and deliberately choose appropriate outlets for it, create direct commercial relations with those publishers, and thus reduce the need for multiple auctions and multiple forms of tracking. There is no inherent conflict between advertising that is more effective (and less intrusive), healthy competition, and reduced emissions. They can work hand-in-hand.

Bio

Donald MacKenzie’s research (with Edinburgh University colleague Charlotte Rommerskirchen and the New School’s Koray Caliskan) is funded by the UK Economic and Social Research Council.

Main sources

Here's how I calculate the approximate puff size. I'm taking Kotila's [estimate](#) of between 0.08 and 1.09 grams per impression. From this [calculator](#), a gram of carbon dioxide at standard temperature and pressure occupies 0.545 litres, or 2.3 American cups (a standard American cup is 0.237 litres).

I draw the estimate of 400 billion ad impressions per day from the same [Kotila article](#). I simply divide by 365 “the expert opinion of 146 trillion ad impressions per annum.”

My estimate of ICT’s emissions of 2-3 percent comes from the UK Parliamentary Office of Science and Technology [PostNote 677](#). The upper estimate of 4 percent comes from Freitag et al. ‘[The Real Climate and Transformative Impact of ICT](#)’, *Patterns* 2 (10 September 2021).

For aviation’s climate impact, I draw upon this [overview article](#) that says that aviation “accounts for around 2.5% of global CO₂ emissions, but 3.5% when we take non-CO₂ impacts on climate into account.”