The Environmental Impact of Digital Preservation

NASA photo ID AS11-44-6552.
https://nssdc.gsfc.nasa.gov/planetary/lunar/images/as11_44_6552.jpg

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Digital Content and the Environment

Every action by individuals, organizations, corporations, governments, and cultural heritage organizations impacts the environment.

Storing and managing digital content intersects with the environment through:

1. Greenhouse gas emissions (energy use)

2. Direct toxic endangerment to people: Hardware, video, audio, film, and data storage media e-waste disposal (and depleting the Earth's natural resources)

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Anthropocene epoch

Anthropogenic climate change: Human activity is the main driver impacting climate change by contributing to the increase in Greenhouse Gases (GHG).

Global consensus: An increase of 2° C (3.6° F) will result in extremely dangerous climate change:

- warmer ocean = dead sealife = no food
- melting ice = flooded coastal areas, **methane gas** (**28x more GHG than CO_2**)
  released from melting permafrost (and ancient bacteria?)
- severe weather (hurricanes, cyclones, drought, wildfires)
- less potable water, less food
- starvation and suffocation; human migrations (climate refugees)
- wars

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From Paris 2015, to Glasgow 2021

2015 goal (COP21):

Global temperature should not rise more than 1.5˚ C (2.8˚ F) from the pre-Industrial era by 2100.

2021 goal (COP26):

Don’t let it increase 2° C (3.6° F). This increase will result in extremely dangerous climate change.

The world must take drastic steps within the next 10 years.

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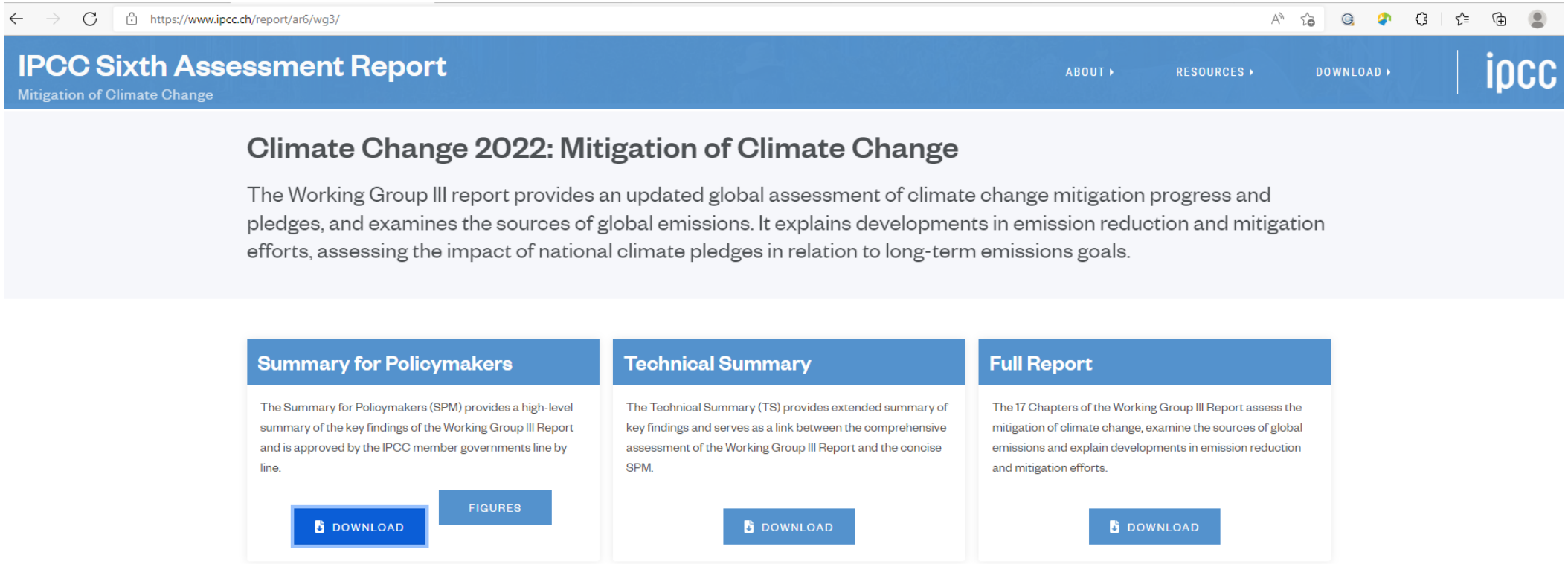
IPCC report on Mitigation of Climate Change (April 2022)



The Intergovernmental Panel on Climate Change (IPCC) is the United Nations body for assessing the science related to climate change. https://www.ipcc.ch/about/

https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/
Released 2022-04-04

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From Paris 2015, to Glasgow 2021, to 2022….

2022 reality:

The global temperature has **already been raised by 1.1˚ C.**

Now it's **impossible to keep it to no more than 1.5** (**2.8˚ F**) (we should reach that by 2030).

<u>We are in a climate emergency.</u>

IPCC 6th Assessment report: "Projected global emissions from [national pledges] place limiting global warming to 1.5C beyond reach and make it harder after 2030 to limit warming to 2C."

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Carbon Footprint

Individual actions (responsibility is on **individuals** and their personal choices).

Examples: recycling, taking public transit,
buying electric vehicles,
installing solar panels, etc.

The term “carbon footprint” was propagated by BP to deflect its corporate responsibilities in GHG production, and place primary responsibility on individuals’ actions.

Kaufman, Mark. “The carbon footprint sham.” *Mashable.* 2020-07-13. https://mashable.com/feature/carbon-footprint-pr-campaign-sham

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Climate Shadow

Term coined by **Emma Pattee:**

"Think of your **climate shadow** as a dark shape stretching out behind you. Everywhere you go, it goes too, tallying not just your air conditioning use and the gas mileage of your car, but also how you vote, how many children you choose to have, where you work, how you invest your money, how much you talk about climate change, and whether your words amplify urgency, apathy, or denial."

Pattee, Emma. "Forget your carbon footprint. Let's talk about your climate shadow." *mic.com* 2021-10-12
https://www.mic.com/impact/forget-your-carbon-footprint-lets-talk-about-your-climate-shadow

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Our archives intersect with ICT (Information and Communication Technology) through energy consumption and hardware use that are required to keep our digital files alive and usable.

Percent of ICT emissions

1. end-user devices	**[your computer]**	**(2011: 60%**	**2030: 47.2%)**
2. telecommunication networks	**[streaming ISP]**	(2011: 22%	2030: 24%)
3. data centers	**[Zoom, Facebook, YouTube]**	(2011: 17%	2030: 28.8%)

It's expected that:

1. end-user devices emissions will **decrease** due to devices' reduced direct and indirect emission rates
2. Data centers will **increase** even with mitigations in efficiency and cooling

#SMARTer2030: ICT Solutions for 21st Century Challenges. GeSI. 2015. http://smarter2030.gesi.org/downloads/Full_report.pdf

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The Environment and Digital Collections

Archives intimately understand the dangers that climate change presents to their collections.

- Heat and humidity contribute to archival collections' deterioration.
- Rising sea levels causes flooding during storms, and overcomes land over time.
- Wildfires, tornados, and hurricanes destroy buildings and collections.

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With physical collections at risk from natural deterioration and End of Life (especially magnetic audio and videotape),

and climate change placing all collections at risk,

archives are increasingly digitizing their collections for preservation and access

(and receiving born digital content to store and preserve as well).

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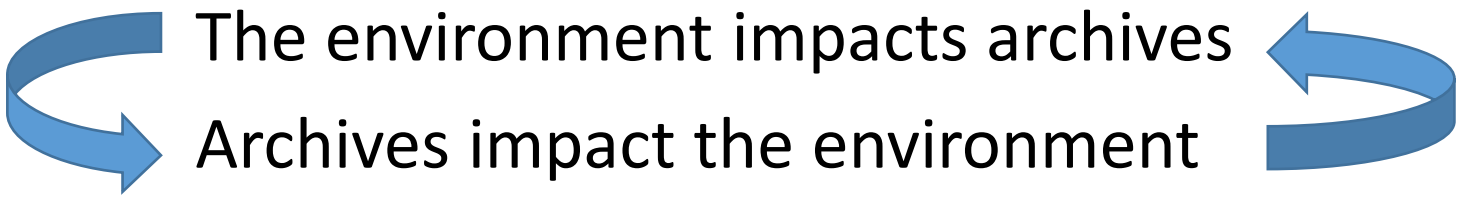
Using digital technologies implicates archives in contributing to climate change.

Archives and the environment have a circular relationship:



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What can archives do to mitigate their environmental impact?

How can archivists and individuals decrease their climate shadows?

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Preserving digital content and making it accessible will impact the environment through:

Legacy media destruction: original audio and video magnetic media items will ultimately be **destroyed**.

Electricity use: data must be preserved and made accessible through storage and management, using **energy resources** that can be dirty or clean.

Hardware/media destruction: Media and hardware used to store and manage the data will be changed every 5-10 years, with the old media/hardware either **recycled, incinerated, or dumped in a landfill.**

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Data is heavy.

By 2025:

The amount of data being **stored** globally from all sectors will reach 175 zettabytes.*

Half of that data will be stored in the public cloud.

Mass data migrations from obsolete generation data tape and older drives will add to the data storage tsunami.

** Data Age 2025: The Digitization of the World – From Edge to Core.* IDC, 2020.

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There isn’t enough data storage media to store all that data.

The planet doesn’t have enough raw materials to manufacture traditional storage media *ad infinitum*.

Yet, 54 million tons of e-waste is produced globally each year.

Data storage media is shredded rather than undergo materials reclamation.

22 million hard disk drives age out at North American data centers every year. **The vast majority are shredded.**

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Data storage materiality

Data storage devices don’t last forever.

When their useful life is over, they’re disposed of one way or another.

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Electronics products lifespans

- **Initial service life** (original owner use): 2-8 years
  - Manufacturers also build-in “end of life” as new models are released
- **Second service life** (after original owner to end of life): (5-20 years)

End-of-life options (e-waste):

- Landfill
- Incineration
- Recycling
- Exportation

E-waste: cables, monitors, computers, servers, circuit boards, telephones, data storage devices, batteries, etc.

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E-waste can contain:

- Heavy and rare earth metals
- Plastic

Consider the recycling potential of your storage media and devices.

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Depleting the planet of its natural resources

Heavy and Rare earth metals

Heavy and rare earth metals: used in making phones, computers, TVs, servers, external hard drives, solid state drives, magnets, batteries – anything electronic. Rare earth metals are used in solar energy technology, lasers, automobiles….

Less than one percent of rare earth elements are currently recycled.

Heavy metals are toxic by their nature. They include: mercury, arsenic, copper, aluminum, lead, cadmium, chromium, cobalt, nickel, zinc, selenium, silver, antimony, and thallium.

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Depleting the planet of its natural resources

Silica sand used to make electronics and glass is also a finite natural resource.

Helium to make hard drives spin cooler and use less energy.

Purified water in making microchips.

Water is used to chill data centers: a mid-sized data center uses 300,000 gallons of water per day.

Climate change and stripping the Earth of its natural resources are each impacting the supply chain.

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Plastic e-waste (e-plastic)

Recycling plastic is an established industry, with methods for recycling plastic bottles the best-established.

Plastics in computers, servers, phones, monitors, video and data tape shells have different formulations so the plastic parts must be separated for recycling and processing.

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Data storage

Digital files must be stored and managed on storage media.

Facebook data center (Altoona, Iowa) powered by a wind farm.

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Data storage options

Physical carriers:

- Spinning disk (hard drives)
- NAND (Solid state/flash)
- Data tape (eg, LTO)

(the “cloud” sits on a mix of these three data storage carriers)

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Circular economy

Most of the carbon emissions are from manufacturing, not from use.

Consider the LCA (Life Cycle Assessment) of media.

What can be reclaimed?

How can you participate in a Circular Economy?

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Data storage options: Spinning disk

Servers (single or networked; using HDDs / SSDs)

Electricity use: High

- Fans in enclosures; power to operate/process
- Environment must be maintained at constant temperature
- **Helium-filled hard drives reduce energy use by 23%** (but helium is a finite natural resource)

Life expectancy: Drives & parts replaced every 3-5 years (initial service life)

Potential recyclable parts: plastics, rare earth metals, magnetic material, heavy metals (copper, aluminum, steel). Server cases & motherboards have re-use potential (2nd life).

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Recycling spinning disks: manufacturers' perspective

Manufacturers know there is a finite amount of raw material to build their products.
They're working towards reclamation solutions.

"…[T]he market demand for data storage is outpacing the ability of HDD and SSD manufacturers to keep up with demand."

But difficult for recyclers to disassemble ("death by screws"). Calculate cost to dissemble and recycle raw materials value vs. simple shredding.

International Electronics Manufacturing Initiative (iNEMI). *Value Recovery Project, Phase 2*. (August 2019)
http://thor.inemi.org/webdownload/2019/iNEMI-Value_Recovery2_Report.pdf
https://www.inemi.org/content.asp?contentid=628

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Material recovery if components are harvested:

- Aluminum substrate (largest raw material)
- Magnetic coating (rare earth material)

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Promising recent efforts: Dell, Seagate, Teleplan

2019: Dell, Seagate, and Teleplan developed method to scrape rare earth metals and magnets from HDDs and recycle into new devices.

By October 2021, over 19,000 pounds of recovered and recycled magnets have been installed in Dell and competitor products. https://www.delltechnologies.com/en-us/blog/what-goes-around-comes-full-circle/

Seagate 2023 report: 1.16 million refurbished HDDs and SSDs in FY22 (540 metric tons e-waste) https://www.seagate.com/esg/ https://www.seagate.com/esg/planet/product-sustainability/

https://www.storagenewsletter.com/2023/05/02/seagate-report-on-transitions-more-operations-to-renewable-energy-and-ramps-circularity-program/

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Promising recent efforts: Seagate and Open Compute Project (OCP)

Holding discussions with hyperscalers to work on security protocols, so they feel secure to recycle the drives (not just shred).

22 million hard disk drives age out at North American data centers every year.

They are shredded. Companies fear litigation of client data on a drive is released on a decommissioned drive.

Open Compute Project (OCP): https://www.opencompute.org/

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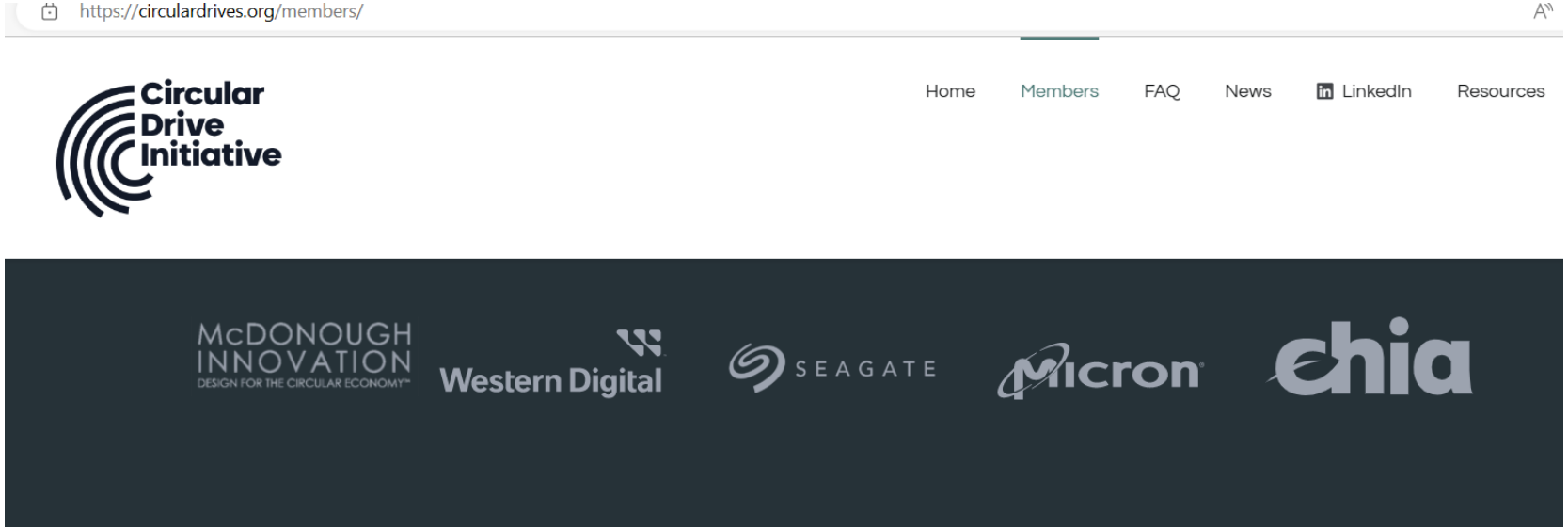
Promising recent efforts: Circular Drive Initiative (CDI)

"The Circular Drive Initiative (CDI) is a partnership of global leaders in digital storage, data centers, sustainability, and blockchain collaborating to reduce e-waste by enabling, driving, and promoting the secure reuse of storage hardware."

https://circulardrives.org/ Website has news, resources to follow.



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Promising recent efforts: Google and data centers

Google is developing technologies to reclaim magnets from data center HDDs.

These are **enterprise HDDs**, not consumer HDDs.

Stone, Maddie. “Can you recycle a hard drive? Google is quietly trying to find out.” *Grist*. August 2021

https://grist.org/technology/can-you-recycle-a-hard-drive-google-is-quietly-trying-to-find-out/

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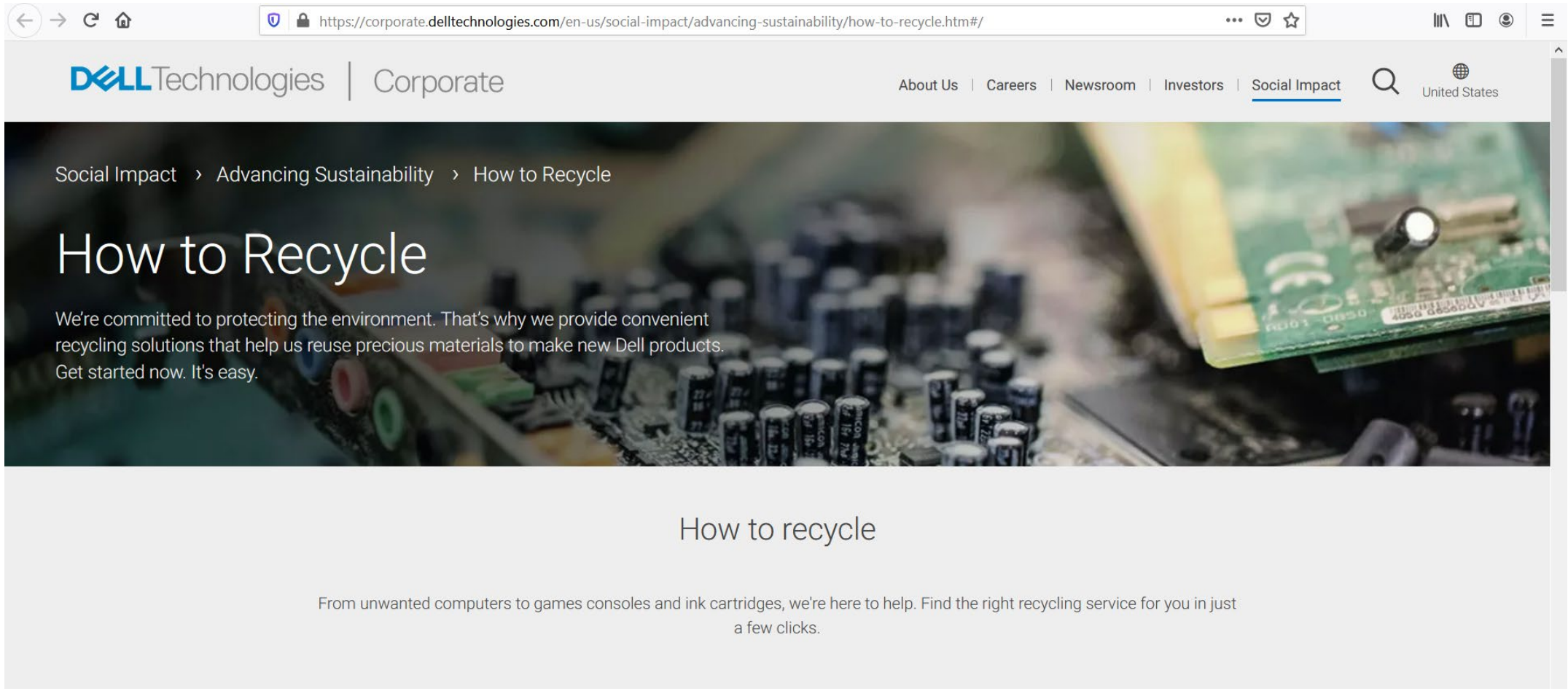
https://corporate.delltechnologies.com/en-us/social-impact/advancing-sustainability/how-to-recycle.htm#/ [This is an international program]



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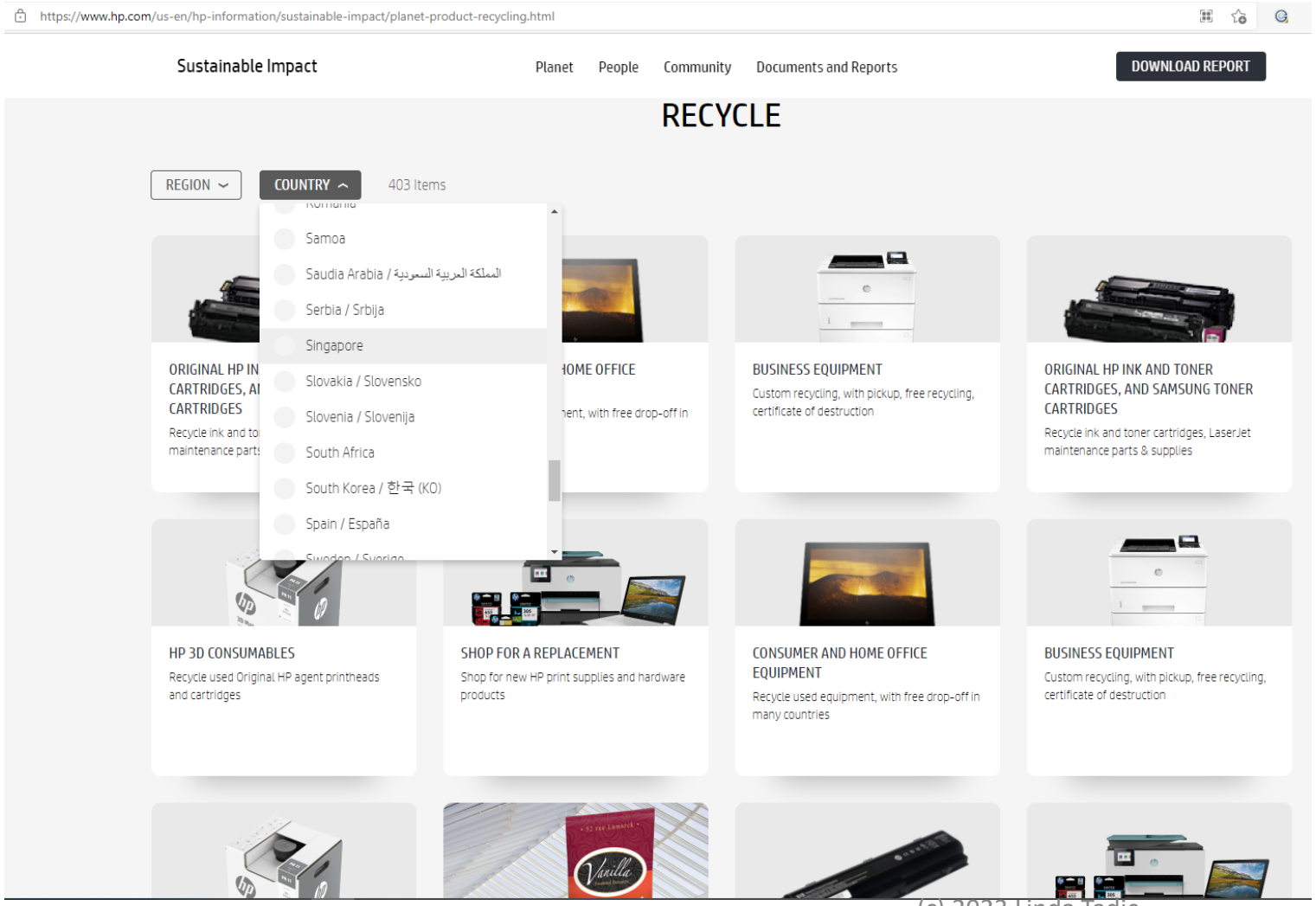
https://www.hp.com/us-en/hp-information/sustainable-impact/planet-product-recycling.html [this is an international program]



HP has a global consumer and business recycling program.

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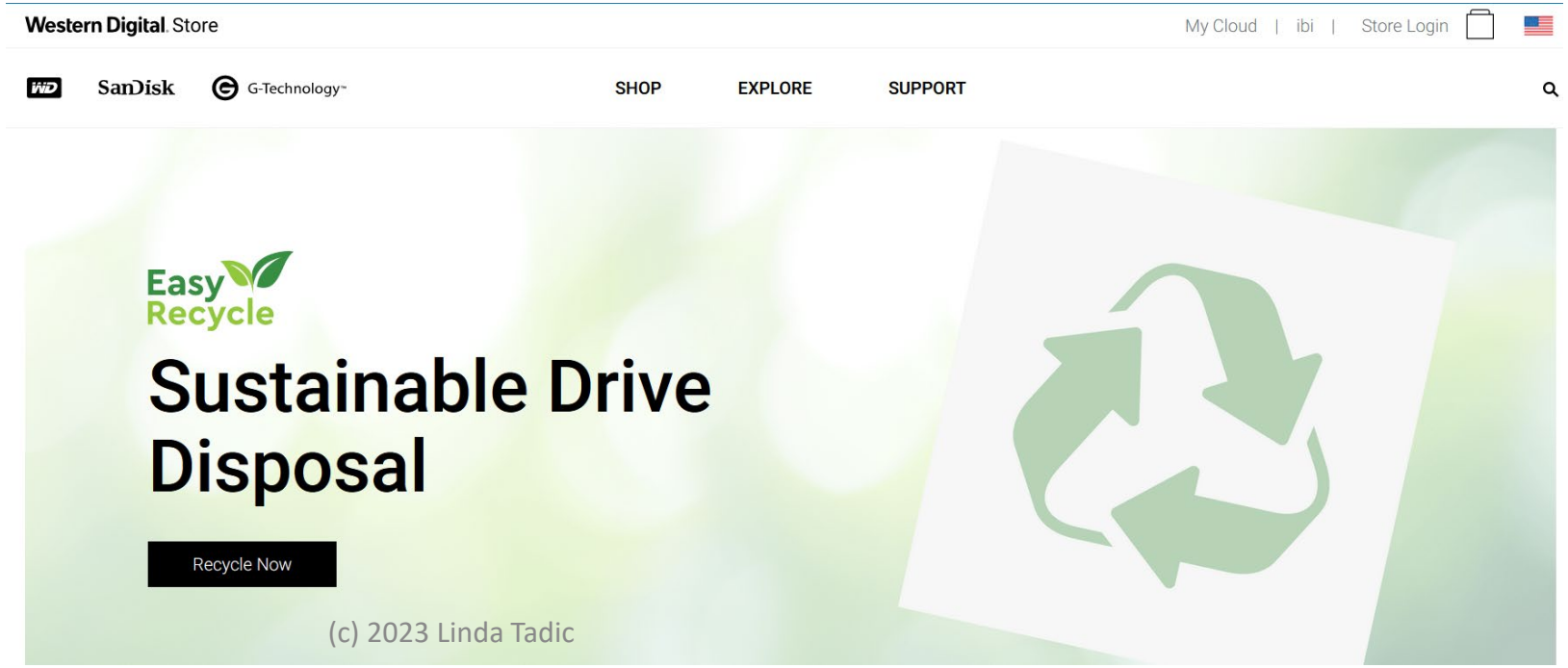
Promising recent efforts

Western Digital recycling program for HDDs and SSDs. Drives from any manufacturer. Consumer-oriented (limit of 5 drives at any one time). (April 2020; US-only)

https://shop.westerndigital.com/campaign/landing/easy-recycle



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Data storage options: NAND Flash Memory on Solid State Drives (SSD)

- No moving parts (power down when not in use)
- Finite number of writes; infinite number of reads
- Fewer natural resources used in the final product

Electricity use: Low-medium

- Powered up only when used, but uses a lot of power when starting up
- Works in extreme environments (up to 85°C / 185° F)

Life expectancy: Depends on number of writes. Data “fades” (loses bits) over time; not a good archival storage medium. Can “fade” even when sitting inert on shelf.

Potential recyclable parts: silicon, copper

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But SSDs emit more CO2 overall than HDDs

Taking into account the LCA over 5 years (comparing a 1TB SSD and 1TB HDD):

The SSD uses less energy while in use:

SSD: 56.9 kWh

HDD: 183.9 kWh

But the overall CO2 output:

SSD: 184 kg

HDD: 99.6 kg

https://basic-tutorials.com/news/ssds-cause-more-co2-emissions-than-mechanical-hard-disks/

https://hotcarbon.org/ *Hot Carbon 2022: 1st Workshop on Sustainable Computer Systems Design and Implementation*

https://arxiv.org/pdf/2207.10793.pdf "The Dirty Secret of SSDs: Embodied Carbon." Tannu, Swamit and Prashant J Nair. *arXiv*, 8 July 2022.

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Chia cryptocurrency mining destroying SSDs

From “Cloud and Storage: Scaleway and Abusive Chia.” (2021-05-24)

https://www.storagenewsletter.com/2021/05/24/cloud-and-storage-scaleway-and-abusive-chia/

Scaleway is a cloud storage provider based in France.

“In order to service as many clients as possible, we have decided that from today:

“Chia plotting is forbidden on all SSD and NVMe powered instances, dedicated servers, RPN-SAN, BMaaS and block storage services. ***Chia plotting is extremely I/O intensive and destroys most SSDs in under a few weeks.***

Important notice: Chia plotting engages client responsibility according to Section 9 of our contract. We will bill clients for any SSDs and NVMes destroyed due to Chia plotting activities.”

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Co2 emitted by AI and machine learning tools

Using AI, ML, and autonomous cars requires extensive compute power in data centers.

ML CO2 impact calculator: https://mlco2.github.io/impact/

“Green Intelligence: Why Data And AI Must Become More Sustainable.” Bernard Marr. Forbes. March 22, 2023.

https://www-forbes-com.cdn.ampproject.org/c/s/www.forbes.com/sites/bernardmarr/2023/03/22/green-intelligence-why-data-and-ai-must-become-more-sustainable/amp/

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2021 Global storage media & computing supply-chain shortage

1. **Microchip and semi-conductor shortage** (Spring 2021)

   Manufacturing microchips is water-intensive. Pandemic plus drought in Taiwan contributed to a slow-down in production.

2. **Shortage of HDD and SSD from Chia cryptocurrency use**

   https://www.datacenterdynamics.com/en/news/chia-cryptocurrency-comes-for-the-hard-drive/ (12 May 2021)

As of April 2022, there appears to be a supply correction. But as drought conditions around the world persist, shortages will occur again.

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Data storage options: Data storage tape

LTO has largest market share in data tape.

Electricity use: Low-Medium

- On shelf: no power. In drive or robotic system: low-medium
- Can be used as offline storage (used only when needed)
- Environment must be maintained at constant temperature (but higher than electronics)

Life expectancy: “30 years” but in reality, you replace every 2-3 generations (LTO-7 released Dec. 2015, LTO-8 Oct 2017, LTO-9 2021 Q4).

Potential recyclable parts: plastics, screws (metal). No process yet to separate mylar ribbon (recyclable) from barium ferrite (BaFe), metal particle, or other components. Generational obsolescence, finite number of “reads,” and WORM technology limits this medium’s re-usability.

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Recycle your drives, LTOs, and media at certified e-waste facilities

International resources:

R2:

https://sustainableelectronics.org/find-an-r2-certified-facility/

E-Stewards:

https://e-stewards.org/

SIMS Lifecycle Services:

https://www.simslifecycle.com/locations/

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Data storage options: “Cloud” (e.g., storing your files on other people’s servers)

“Cloud” **storage**: You pay for what you use, and don’t need to purchase hardware (no organizational storage e-waste).

Using the cloud **CAN** be helpful in its economies of scale. Cloud provider manages hardware, power, air conditioning.

You don’t need to keep buying the hardware which becomes e-waste.

Electricity use is optimized (***maybe***).

Collections’ access can be global, not just local.

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Carbon neutral?

Archives, universities, and businesses incorporate cloud storage into a “carbon neutral” strategy –

But sometimes “**carbon neutral**” means **using someone else’s carbon.**

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The “Cloud” has a heavy weight

Consider your vendor’s power source. Is it **dirty**?

Data centers use 3% of the world’s electricity. In 2010: 1%

- The 6 major “cloud” service providers are moving towards using 100% renewable energy: Apple, Box, Facebook, Google, Salesforce and Rackspace.
- Facebook, Google, and Apple are investing in building wind and solar farms to power their dedicated-built data centers and to supply neighbors.
    - **BUT** most of their servers are in third-party data centers (renting space)

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Global data centers map. https://baxtel.com/map

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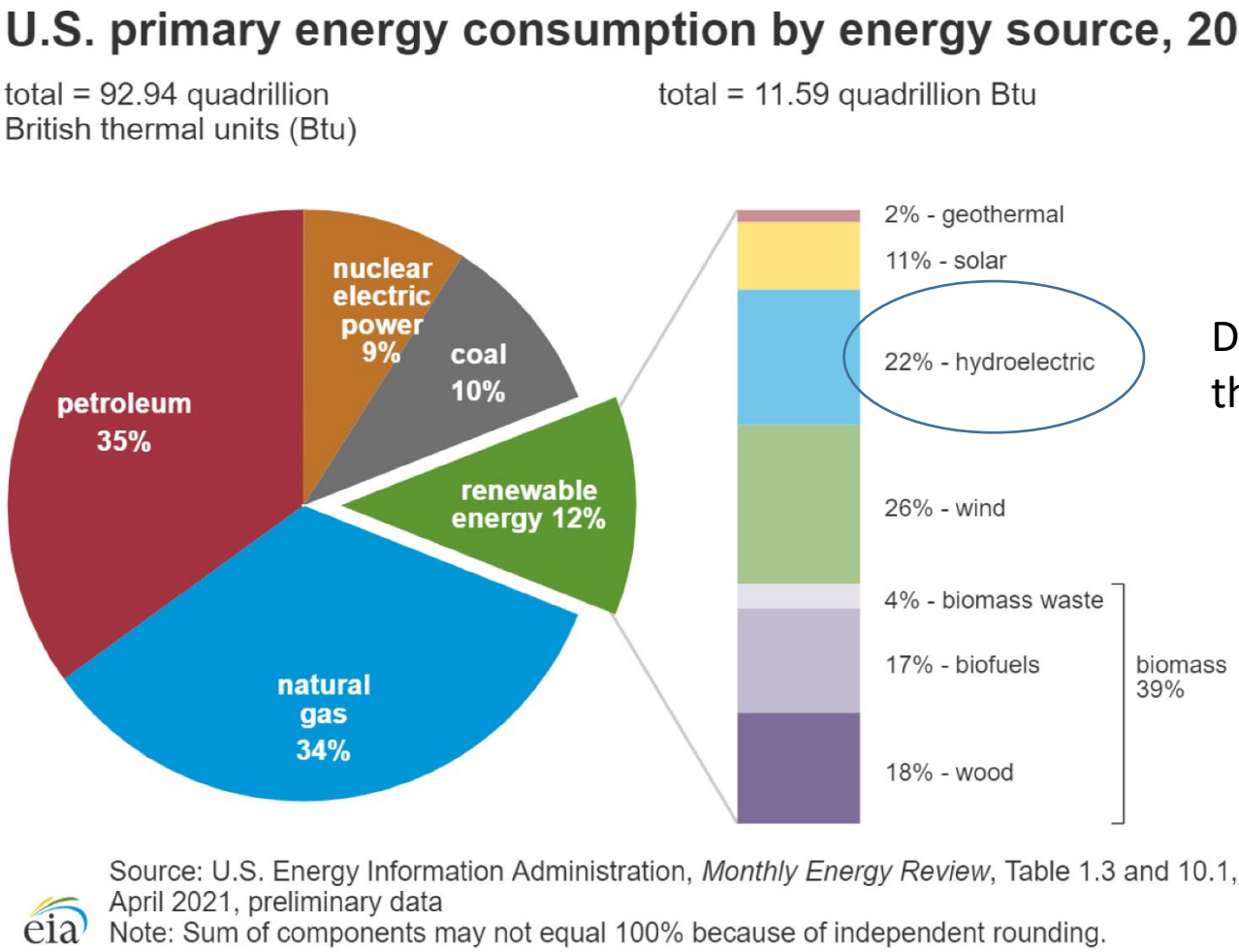
Data centers' (and your) energy sources



Droughts caused by climate change threaten hydroelectricity output.

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https://www.eia.gov/energyexplained/us-energy-facts/

Data centers and water use

A mid-sized data center consumes around **300,000 gallons of water a day**, or about as much as 1,000 U.S. households. Their direct, on-site consumption ranks data centers among the top 10 water users in America's industrial and commercial sectors.

In the United States, there are about 2,600 data centers, many of which are clustered around Dallas, the San Francisco Bay area and Los Angeles.

https://www.npr.org/2022/08/30/1119938708/data-centers-backbone-of-the-digital-economy-face-water-scarcity-and-climate-ris

Data centers keep cool by either using chilled water tanks (uses more electricity), or evaporative cooling (uses more water).

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Data centers and the circular economy

Google says 27 percent of the components it used in server upgrades in 2021 were refurbished inventory and that it overwrites data on its hard drives for reuse “where possible.”

Amazon: shreds all drives after 3-5 years of use.

Microsoft now operates several “circular centers” for refurbishing old servers and says more than 80 percent of its decommissioned assets will be repurposed by 2024. But for hard drives, shredding is still the norm.

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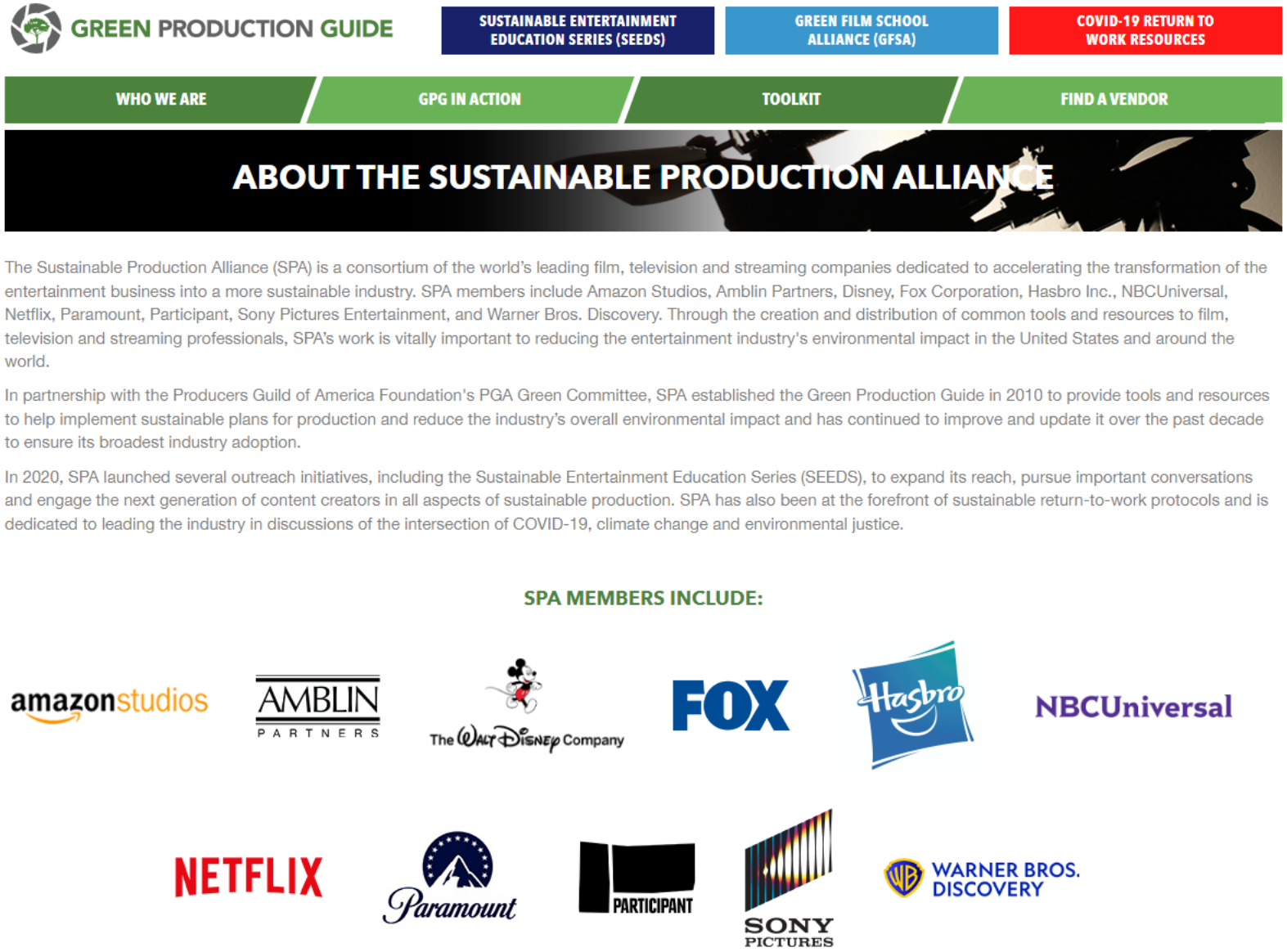
Media & Entertainment production efforts to lower GHG

Sustainable Production Alliance (SPA)

https://www.greenproductionguide.com/

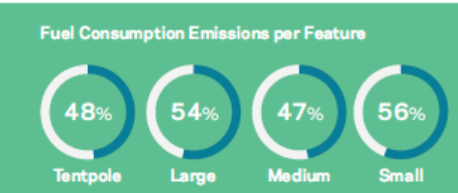
Developed the “Green Production Guide”



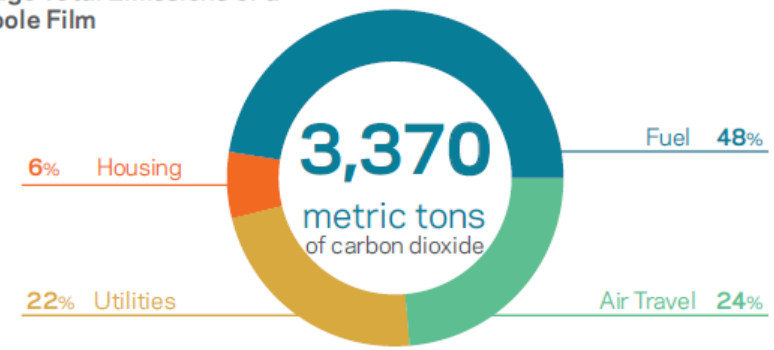
SPA Report: Carbon Emissions of Film and Television Production (March 2021)

https://www.greenproductionguide.com/wp-content/uploads/2021/04/SPA-Carbon-Emissions-Report.pdf

Across all feature films, the largest contributing factor was fuel consumption. Fuel is mainly used in production vehicles and generators.



Average Total Emissions of a Tentpole Film



- For tentpole productions, fuel consumption made up nearly **48%** of the average footprint.
- For all feature film productions, air travel and utilities contributed relatively equally to the overall carbon footprint. For tentpoles, air travel and utilities contributed about **24%** and **22%** of the carbon footprint, respectively.
- Accommodations such as hotels and housing accounted for the smallest amount of carbon emissions, contributing only **6%** to tentpole films.

SPA resources

Toolkit to help production monitor their carbon footprint:

https://www.greenproductionguide.com/tools/

Database of green vendors:

https://www.greenproductionguide.com/green-vendors/

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“Carbon Impact of Video Streaming”

Report from Carbon Trust (2021):

https://prod-drupal-files.storage.googleapis.com/documents/resource/public/Carbon-impact-of-video-streaming.pdf

50% of ICT emissions is from end-user devices, not from data centers. (p. 30)

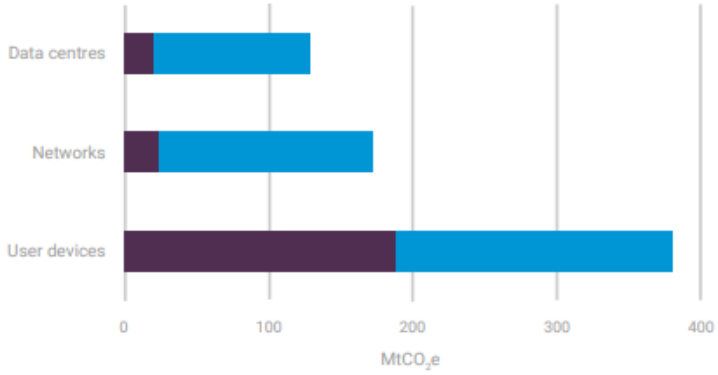
2.6.3 End-user devices

User devices make up the largest portion of carbon emissions of ICT. The emissions of end-user devices making up just over 50% of ICT's overall footprint (shown by Figure 10 below) with the largest portion coming from PCs and laptops (Malmodin 2020a). Malmodin (2018a) suggested that the emissions contribution of user devices decreased between 2010-2015. This is due to technology efficiency trends in user devices, and the trend to use smaller devices (e.g. from PCs and laptops to tablets and smartphones).

Changes in types of user devices:

There is an increasing shift in ICT user device preferences from larger PCs and laptops to mobile devices, supported

Figure 10. Breakdown of ICT sector emissions by component



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Signs that sustainability efforts are becoming normalized

- Organizations moving away from all-cloud to hybrid model.
- LTO is considered part of a “green” solution to data storage.

Library of Congress Designing Storage Architectures annual meeting (March 2023) https://digitalpreservation.gov/meetings/storage23.html

National Association of Broadcasters (NAB) April 2023 show had a focused theme on “sustainability.”

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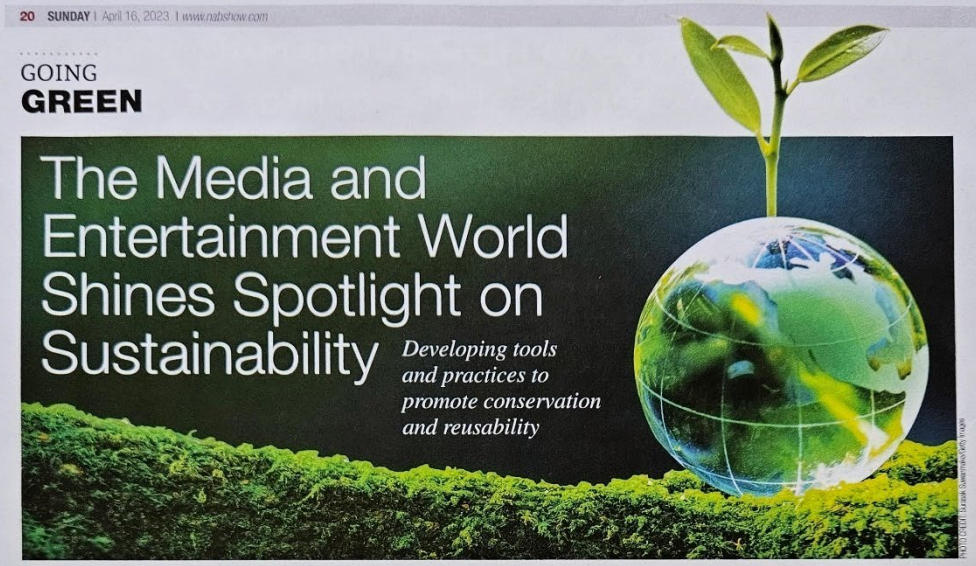
NAB Show Daily News, April 16, 2023

GOING
GREEN

The Media and Entertainment World Shines Spotlight on Sustainability

Developing tools and practices to promote conservation and reusability



By Peter Suciu
TV TECH

Even in the best of times, there are plenty of short-term reasons not to consider the greenest option, such as the expense of replacing legacy hardware that is doing the job. In today's economic climate, going green is even harder.

"Times of inflation, low growth and recession are notoriously difficult times to convince customers to go with more sustainable options," said Tom Kirby, marketing manager at Altadena, Calif.-based Nila Inc. "People tend to think more in terms of short-term gains than long-term ones. It can be hard to get them to see just how much more money they'll save in five years or more with sustainable options. It can also be hard to get them to look past their own needs and see the greater needs of the planet."

Nila has carved out a niche in the market by developing and manufacturing environmentally sustainable, high-brightness LED lighting systems that can serve customers well beyond the present day. But challenges remain.

"We know our customers depend on us for reliability and sustainability, so we can't hedge on either. The result has been that we've been much later getting our new Arina-400 and Zaila-50 products to market than we expected, but we'd rather have delays than compromise the quality of our products," said Kirby.

There also remains a lot more "churn" as the market continues to be driven by the hunt for new products yet too much hardware isn't repairable or upgradable, said Kirby. "It's considered disposable, and it's largely made from materials that aren't recyclable. That's frankly unacceptable. Lighting is a great place to start with sustainable practices because smart purchases can often be utilized for decades."

OFF THE SHELF

Utilizing ready-made equipment can help sustainability efforts, said Barbara H. Lange, principal and CEO of Kibo121, and moderator of the today's panel discussion as part of the NAB Show's Excellence in Sustainability Awards ceremony, "The more you work with off-the-shelf products — as opposed to customizable offerings — you are helping to reduce unnecessary waste. We have to look at energy consumption as an industry across the entire workflow, even if changing habits can be challenging."

> "A common misconception in the production space is that lessening energy consumption is the only method of going "green."

A common misconception in the production space is that lessening energy consumption is the only method of going "green." In fact, that is just one component of it. So, too, are other factors, including reducing water usage and ensuring that today's racks of equipment aren't an electronic waste, or "e-waste," problem for tomorrow.

"We've seen a trend for everyone to have as small a carbon footprint as possible," said Linda Tadic, founder of archival storage firm Digital Bedrock, which to date has preserved 3 PB (parabytes) of data for media and entertainment companies, as well as for museums, law firms and nonprofits.

"We think the discussion needs to turn to the storage waste — and that includes how water is used to cool the data centers, but also how everything doesn't need to spin in the cloud if it doesn't need to be readily accessible," Tadic explained.

Digital Bedrock utilizes LTO data tape, which isn't just a form of storage but also provides long-term preservation. In addition to less energy consumption, it also means there are fewer servers that require rare earth minerals.

"We can do everything on two racks, while we might upgrade to three," said Tadic. "But the goal is to consume less. The cloud isn't light; it is very heavy."

Keeping in mind energy use and e-waste:

What can archives do to mitigate their environmental impact?

How can archivists decrease their carbon shadows?

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Technology: Use less energy

Related to storage. Using less electricity and fewer spinning disks helps the environment plus saves money.

1. **Apply hierarchical storage management (HSM) policies**: Store large and infrequently accessed files offline on data tape. Only store frequently accessed files online (tier 1).

Spinning disk storage takes 26x more energy than storing and infrequently accessing data tapes.

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HSM tiers

Tier 1 (Online): Immediate access from spinning disk or SSD

Tier 2 (Nearline): Can be (1) Stored on tape in a SAN; files accessed from the tape. OR (2) files on HDD with Tier1 on fast SSD

Tier 3 (Offline): Stored on tape or other media off the network

If applied thoughtfully, cloud storage can be part of HSM policies.

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Technology: Use less energy

2. **If store on data tape (LTO):** Migrate to new media every two (or even three) generations LTO (~ every 5-10 years).

More files will be stored on the new generation tape (fewer media items).

Recycle the old data tape through destruction (not re-use) for security, but also since the tape format will be obsolete and overly-used. Data tape has a maximum number of “reads.”

– Recycle the plastic cartridge and metal screws if possible.

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Technology: Use less energy

If you have a server room on-site running current hardware:

3. **Set the server room temperature higher**: 70-80˚ F
   (no more than 27° C / 81° F)

Rooms with data tape:

15 – 32° C / 59 - 89° F (rate of change less than 5° C per hour)

20 – 80% RH (rate of change less than 5% per hour)

ASHRAE, 2022. Thermal Guidelines for Data Processing Environments, Fifth Edition, ASHRAE.
https://www.ashrae.org/technical-resources/bookstore/datacom-series

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Technology: Use less energy

4. Turn off unused servers.
5. Set servers to go to inactive mode when not in use.
6. Consolidate and virtualize several applications on one server.

    - This also results in fewer servers to replace/recycle.

7. Use the cloud for some applications (but verify the provider's "green" record).
8. Question your data/colocation center on its power source and "green" record.

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Technology: Environmental planning

1. Purchase clean energy where possible, not coal-generated.
2. Purchase hardware that is energy efficient.
3. Purchase recycled devices (recycled materials or recycled by re-use).
4. Upgrade servers by upgrading drives (not the entire box)
5. Recycle by re-use when possible.
6. Recycle data tape and hard drives with vendors who strip out parts and recycle components where possible. If media is shredded and incinerated, verify the incineration process.

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Preservation actions

Schedule infrequent fixity checks

This depends on storage medium and system. If the files and storage media are stable, no need to perform more than once a year.

Running fixity checks takes CPU, memory, storage --- all running on electricity.

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Policies

Appraisal policies

Does all digital content acquired or created by the archive require **permanent retention?**

> If retained for a specific period (not permanent), move files between storage tiers, and ultimately delete.

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Policies

Appraisal policies

Does all content acquired or created by the archive need to be digitized/saved at the **highest possible resolution**?

High resolution = large files = large amount of storage to manage.

Store permanent large preservation masters offline.

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Low resolution digital files are better than nothing.

If you have limited resources and budget, it’s better to save the content than fetishize the file format.

Just be sure the format is sustainable (widely used and supported) and can be migrated in the future.

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Set a carbon budget

Work from home as much as possible.

- Less transit use and automobile emissions
- Less oil/gas used, less demand = more investments in renewables

Hold remote conferences or hybrid events.

- On one hand, we're Zoomed-out and want to see each other in 4-D.
- On the other hand, remote events widens the capability of people to participate who otherwise might not be able to travel.
- Online events more environmentally-friendly than in-person.

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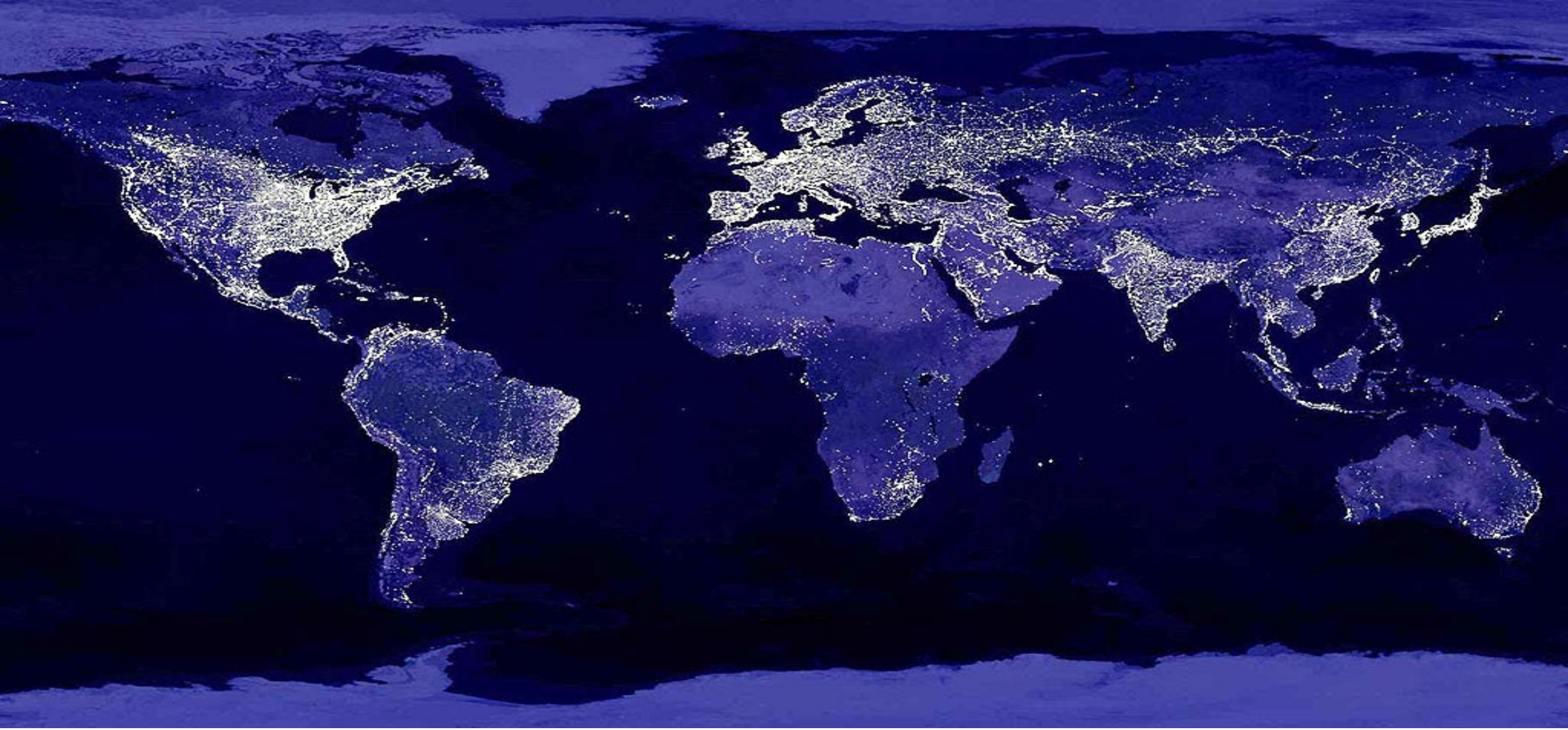

Photo: NASA

Thank you.

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