The Environmental Impact of Digital Preservation

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This presentation will address

1. Overview of environmental concerns directly interfacing with the AV archival community.

2. Choices archives can make to both lower their environmental impact **and** improve their long-term sustainability.

Protecting the environment is a global concern. Our actions can impact regions thousands of miles away.

First, some relevant estimates

How much magnetic media (sound and video) is there in the world that will be migrated to digital files? **What's the extent of our impact?**

- Focus on magnetic media rather than film, since magnetic media <u>must</u> be digitized within the next few decades.

Eventually, there will only be

"media carcasses" on vault shelves.

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Impossible to estimate total number of hours

Audiovisual collections are held by:

- Libraries, archives, museums (cultural heritage organizations)

- Media and Entertainment (studios, broadcasters, independent producers)

- Corporate

- Consumer

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Some attempts at estimates

These estimates are **only** for cultural heritage organizations:

- **UNESCO (2000 report):** 200,000,000 hours globally (video and audio)
- **LC National Recording Preservation Plan (2012):** 46,000,000 hours (audio only; US libraries and archives only)
- **NEDCC report (2015):** 570,000,000 hours (250,800,000 hours migration-worthy) (audio only; US libraries, archives, and museums only)

Library of Congress: In September 2016: 6.8 PB AV content (x2 locations).

Feb. 2016: 64 TB. In 3 years: 1.3 PB per month (both digitized and acquired born-digital).

Let's say 400,000,000 hours total from all sectors (global)

250,000,000 hours audio

150,000,000 hours video

Physical media digitized at a recommended high resolution open file format:

Audio: WAV 96/24 (2 GB per hour)

Video: uncompressed 10-bit (SD) (94 GB per hour)

400,000,000 hours legacy magnetic media = <u>14,600 PB</u>

AUDIO
250,000,000 x 2 GB = 500 PB

VIDEO
150,000,000 x 94 GB = 14,100 PB

TOTAL: 14,600 PB (14.6 Exabytes)

… and that's only one set of files. **2 sets for redundancy: <u>29.2 Exabytes</u>**

Hard numbers:

2012: 430,000 PB of storage media sold (HDD, tape, NAND)*

2015: LTO: 76,190 PB of compressed capacity shipped (about 30,500 raw PB)**

Global IP traffic is expected to reach 1.4 zettabytes by 2017.

1 zettabyte =
        1,000 exabytes =
                1 billion PB

*Fontana, Decad, and Hetzler. "The impact of areal density and millions of square inches (MSI) of produced memory on petabyte shipments of TAPE, NAND flash, and HDD storage class memories." *IEEE 29th Symposium on Mass Storage Systems and Technologies (MSST), 2013*.

** http://www.lto.org/wp-content/uploads/2016/03/LTO_Media-Shipment-Report_3.22.16.pdf

Preserving this content will impact the environment:

Legacy media destruction: 400,000,000 magnetic media items will ultimately be **destroyed** ("media carcasses").

Electricity use: 29 Exabytes of data must be preserved 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.**

Archives can make choices to mitigate their environmental impact AND improve institutional sustainability

Broad areas where choices can be made:

- Staff actions

- Technology choices
  - hardware and media
  - energy use

"Rising temperatures are recognized as
a national security issue, destructive force, and
threat to national economies. The window of
opportunity to address the predicted devastation
associated with our warming planet continues to close.
Accepted is that **ICT [information and communication technology]**
is key to achieving a low carbon economy."

-- GeSI SMARTer 2020 report (2012 revision)
http://gesi.org/SMARTer2020

* Since 2009, the US State Department has a Special Envoy for Climate Change: Todd Stern.

* **Mary Robinson** refers to "climate justice" (social injustice + climate change)

Our archives intersect with ICT through energy consumption and hardware use that are required to keep our digital files alive.

Direct toxic endangerment to people

200 million people are at risk to toxic exposure
- The World Health Organization, in conjunction with the World Bank, estimates that 23% of deaths in the developing world are attributable to environmental factors.

Types of toxin-producing entities ("usual suspects"):
- Coal and oil refineries
- Tanneries
- Chemical manufacturing
- Heavy metals mining and smelting
- Nuclear accidents

And now:
- **E-waste incineration**
- Battery recycling plants

Sign at Cottonwood Springs, Joshua Tree National Park, California (March 2015) [mine closed in 1910]

AREA CLOSED

No off-trail public use or travel is allowed in this area.

Soil contaminated with heavy metals including arsenic, lead and cobalt is hazardous to health.

36 CFR §1.5(f)

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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:

- Landfill
- Incineration
- Recycling
- Exportation

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

E-waste recycling

Cost-benefit: If it costs too much to extract and recycle the metals, the material is dumped.

- electronic waste accounts for more than **90 million tons globally**.
  http://www.mobileindustryreview.com/2014/12/mobile-environment-impact.html

- 71% of desktop computers in US went to landfills (2007).
  Electronics Waste Management in the United States, Approach 2. April 2007. US EPA.
  http://www.epa.gov/epawaste/conserve/materials/ecycling/docs/app-2.pdf

E-waste exportation

Countries export electronics to Asian and under-developed countries for re-use and/or recycling (often calling shipments "second-hand goods" or "metal scrap" to avoid **Basel Convention** ban).

Often the hardware isn't used but stripped of copper and other metals.

80% of US e-waste "Green" recyclers ship their received waste overseas.

http://www.china-underground.com/magazine/inside-china-e-waste-hell

Cellphones

- Contain heavy and rare earth metals: mercury, arsenic, beryllium, cadmium, lead
- Recyclable components: steel, copper, aluminum, glass
- BUT difficult to recycle due to small parts that are glued together.
- Consumers view them as eminently disposable.

(In the US, only 8% are recycled appropriately.)

Catholic.org   (c) 2016 Linda Tadic

How recyclable is your phone?

Score table	More Detail →
Brand	**Rating out of 20**
Fairphone smartphone	15
Doro PhoneEasy	10
Amplicomms mobile	9.5
Alcatel mobile phones	9
Huawei smartphone	8.5
Acer smartphones	8
ZTE mobile phone	7.5
HTC smartphones	7
iPhone smartphone	7
Sony Xperia smartphone	7
Blackberry smartphones	6
Motorola smartphones	5.5
Google Nexus smartphone	4.5
LG mobile phone handsets	4
Nokia mobile phones	4
Samsung mobile phones	3.5
Amazon Fire	2

Some manufacturers are developing phones that are recycle-friendly:

- Easily extracted screws, no adhesives, simple to dismantle.

- Using recycled or biodegradable plastic

http://www.mobileindustryreview.com/2014/12/mobile-environment-impact.html ;
http://www.ethicalconsumer.org/buyersguides/phonebroadband/mobilephones.aspx

Heavy and Rare earth metals

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

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.

Coltan (columbite–tantalite)

- Tantalite used in tantalum capacitors (cellphones, laptops, most electronic devices).

- "Conflict mineral:" Uncontrolled mining in Democratic Republic of Congo: deforestation, eastern mountain gorilla population decreased (habitat destroyed, eaten by miners ("bush meat"); smuggling to support civil conflict

Open burning of e-waste

E-waste is incinerated to extract copper, aluminum and other metals.
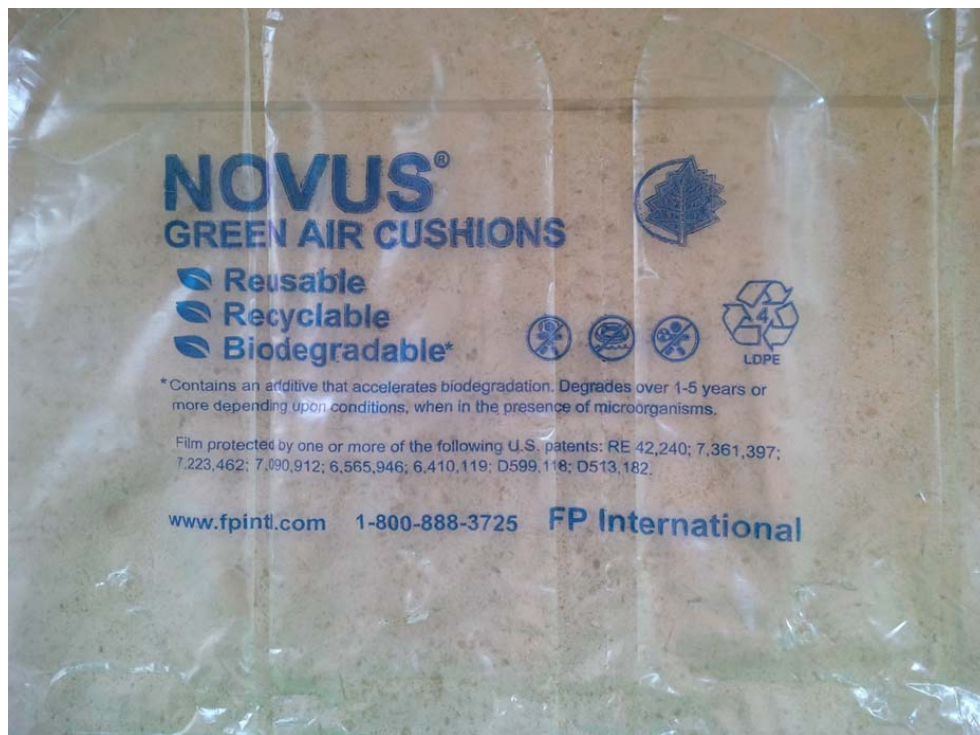
Toxins go into the air and soil.

From the soil, the toxins migrate into groundwater.

(c) 2016 Linda Tadic   © Greenpeace / Kate Davison
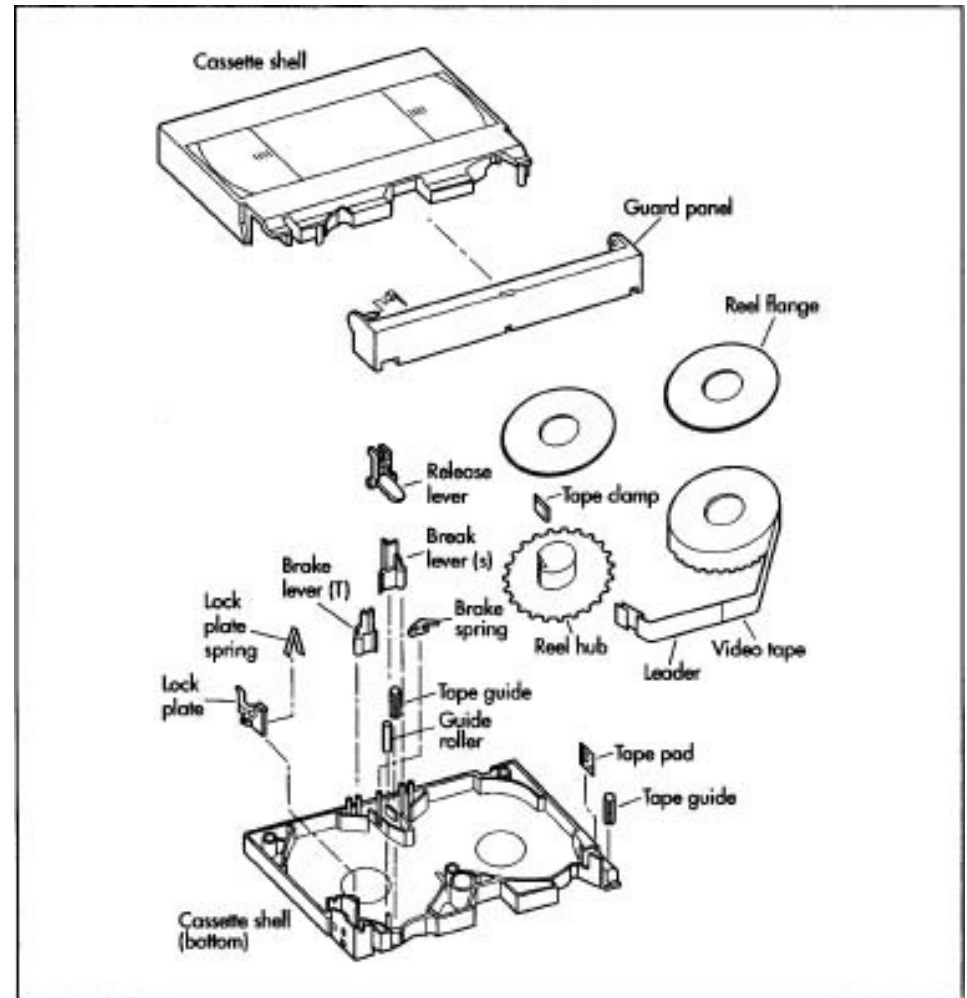
Plastic e-waste (e-plastic)

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.

Videotape as e-waste

Three components for recycling:

1. plastic shell
2. metal screws & parts
3. tape itself

Labels on diagram: Cassette shell, Guard panel, Reel flange, Release lever, Tape clamp, Break lever (s), Brake lever (T), Brake spring, Reel hub, Video tape, Lock plate spring, Leader, Lock plate, Tape guide, Guide roller, Tape pad, Tape guide, Cassette shell (bottom)

http://www.madehow.com/Volume-7/Videotape.html

Videotape as e-waste

Videotape ribbon itself is made of (simplified):

- **Base film**: mylar (PET)
- **Binder**: lubricants, adhesives, polymers (no binder in Metal Evaporated tapes)
- **Magnetic particles**: iron oxide, chromium oxide (CrO2), cobalt, barium ferrite (BaFe)

Mylar base (PET) can be recycled, but currently there is no process to separate the magnetic particles and binder from the mylar.

The raw magnetic materials are toxic; unknown how they will break down in their tape formulations if dumped in landfills.

Creative re-use of tape

Audiocassette tape mixed with yarn to make a purse and Barbie Doll outfit.
http://www.myrecycledbags.com/category/cassette-tape-crafts/

Philip Ob Rey's *"V" HS Project.* http://www.humantropy.com/v-hs-1/

Videotape as e-waste

Recyclers have these options:

1. Shred the full item and incinerate or dump the pieces into a landfill.

2. Disassemble the tape: melt the plastic cassette and screws. Shred the videotape itself, and dump into landfill or incinerate.

Videotape as e-waste: Recycling vendors examples

**Sims Recycling Solutions** (Los Angeles facility now closed):

- Will separate video parts for higher fee since more labor-intensive.
- Videotape is incinerated, following California incinerator regulations.
- Standard procedure is to shred the full case with tape and incinerate.

GreenDisk (Washington State):

- Separates videotape parts.
- Videotape is shredded, but not disposed. 100,000 lbs (45 metric tons) currently stored in a warehouse until a recycling solution is developed.

Data storage

Once the audio/videotape is digitized, the digital files must be stored and managed.
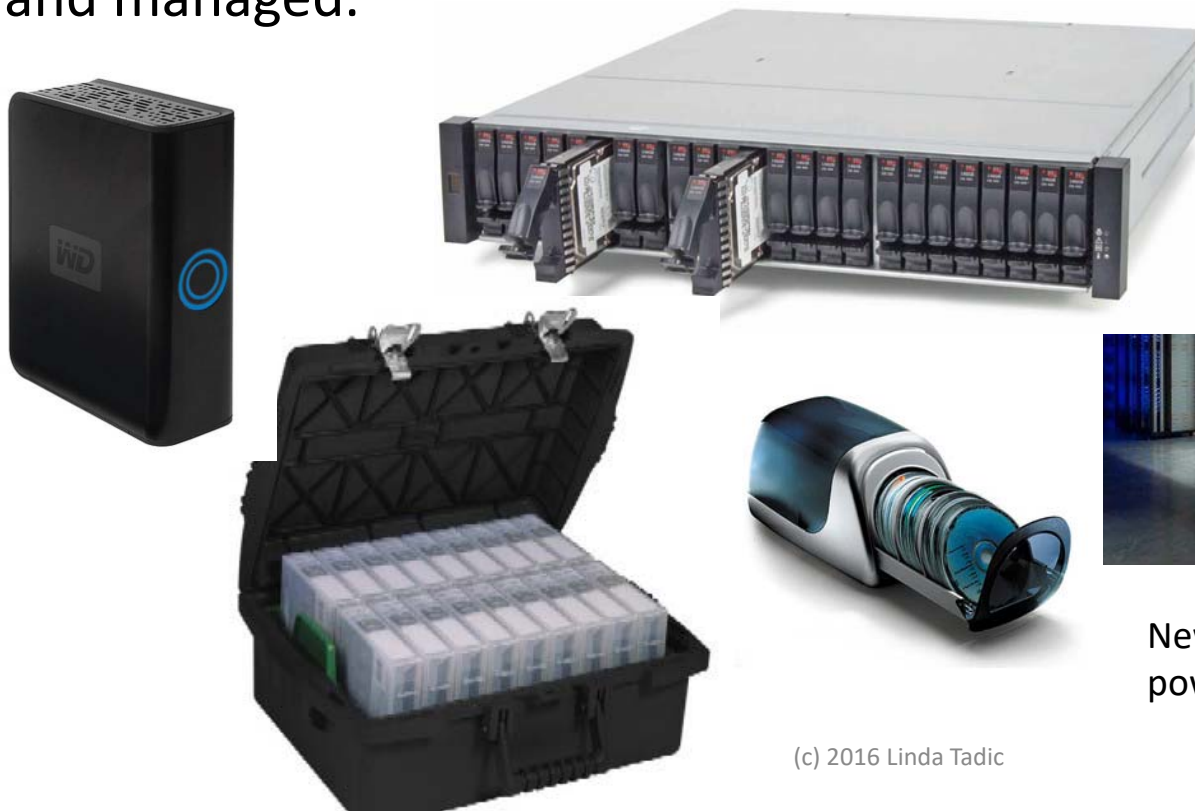
New Facebook data center (Altoona, Iowa) powered by a wind farm.

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Data storage options

Physical carriers:

- Spinning disk (servers, hard drives (HDD)
- Digital tape
- NAND Flash memory on Solid State Drives (SSD)

Often storage is a mix (Hierarchical Storage Management, or HSM):

- online (spinning disk)
- nearline (tape in a robotic system)
- offline (tape or other media not using power)

Data storage options: Spinning disk

Servers (single or networked)

Electricity use: High

- Internal fans; power to operate/process
- Environment must be maintained at constant temperature
- **Helium-filled** drives reduce energy use by 23%

Life expectancy: Replaced every 3-5 years (initial service life)

Potential recyclable parts: plastics, rare earth metals, heavy metals (copper, aluminum, steel). Re-use potential (2nd life), but servers will eventually likely end up in landfills after stripping some metals.

Wasted energy

"Typical servers in the U.S. only use 5 to 15 percent of their maximum capability on average, while consuming 60 to 90 percent of their peak power …. This wasted energy represents the equivalent output of 13 power plants."

"…. **small** server rooms and closets account for over 50 percent of data center energy use in the U.S. … **30 to 70 percent of electricity** use comes from powering and **cooling** servers running 24 hours a day."

-- *Are There Ghosts in Your Closet? Saving Wasted Energy in Computer Server Rooms*. National Resources Defense Council (2012). http://www.nrdc.org/energy/files/Saving-Energy-Server-Rooms-FS.pdf

Air conditioning and HFCs

Air conditioners emit hydrofluorocarbons (HFCs), **1000 times** more potent a GHG than carbon dioxide.

Kigali (Rwanda) Accord (10/15/2016) will globally phase out HFCs by 2047. More specific than Paris accords. *"Will lead to the reduction of the equivalent of 70 billion tons of carbon dioxide from the atmosphere — about two times the carbon pollution produced annually by the entire world."* **Could decrease global temperature 1° F.**

-- http://www.nytimes.com/2016/10/15/world/africa/kigali-deal-hfc-air-conditioners.html?emc=eta1

Chemical industry is already developing replacement technologies.

Microsoft data center in the ocean? Project Natick

- Ocean water cools the servers, which must last 5 years
- Uses electricity from the moving seawater
- Heat doesn't expand beyond a few inches (for this small unit)
- Cables attached to land

http://natick.research.microsoft.com/

http://www.nytimes.com/2016/02/01/technology/microsoft-plumbs-oceans-depths-to-test-underwater-data-center.html?_r=0

Data storage options: Spinning disk

External hard drives (single or networked)

Electricity use: Low-medium
- Internal fans; power to operate
- Can be used as offline storage (powered up only when needed)
- Environment must be maintained at constant temperature

Life expectancy: Replaced every 3-5 years

Potential recyclable parts: plastics, rare earth metals, heavy metals, magnets. Failure rates make this medium not as re-usable as servers. Likely candidate for landfills.

Data storage options: Data storage tape

LTO, Oracle (Sun/StorageTek) T10000 series, IBM 3592

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: LTO: Replaced every 2 generations (LTO7 released Dec. 2015)

Potential recyclable parts: plastics, screws (metal). No process yet to separate mylar (recyclable) from barium ferrite (BaFe), metal particle, or other components. Generational obsolescence, limited number of "reads," and WORM technology makes this medium not re-usable. Tape ribbon not recyclable.

Spinning disk and tape: Total Cost of Ownership (TCO)

TCO includes: cost of hardware, maintenance, media, energy, floor space. **TCO for disk-based storage is 26 times that of tape-based**.

- Cost of **energy**: disk-based storage uses **105 times** more energy than tape-based
- Floor space: disk needs **4 times** the space as tape
- Cost of media is 25% the TCO for tape-based solution

Mixed storage:
- With 50% on tape, the TCO is reduced by 48%
- With 90% on tape, the TCO is reduced by 87%

This doesn't include staff costs.

-- *Revisiting the Search for Long-Term Storage: a TCO Analysis of Tape and Disk.* The Clipper Group Calculator. (2013)
http://www.clipper.com/research/TCG2013009.pdf

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

- No moving parts (power down when not in use)

- Runs cooler than spinning disk

- Finite number of writes; infinite number of reads

Electricity use: Low-medium

- Powered up only when used, but uses a lot of power when starting up
- Works in extreme environments (up to 70°C / 158° F)

Life expectancy: Depends on number of writes.

Potential recyclable parts: silicon, copper; no rare earth metals.

Data storage options: "Cloud" (e.g., storing your files on other people's servers)

"Cloud" **storage (<u>not</u> preservation)**: online or nearline (tape). You pay for what you use, and don't need to purchase hardware. Economies of scale is a plus.

BUT ---

Consider your vendor's power source. Is it **dirty**?
- 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 data centers and to supply neighbors.

Amazon Web Services (AWS)

Amazon Web Services (AWS) is a "dirty energy" cloud provider, but is just starting to talk about change.

AWS US-East region (Northern Virginia) is their largest site.
- 10 data centers using energy largely produced by coal, nuclear, and gas-powered plants (only 2% renewable energy). Their energy provider is building out even more fossil fuel-burning plants to meet Amazon's needs.

June 2015: Amazon announced it was partnering to build a wind farm in Indiana. Claims it uses 25% renewable energy, with a goal of using 40% renewable energy by 2016, 50% by 2017. But no data released to support their claims.

Company Scorecard

	Clean Energy Index	Natural Gas	Coal	Nuclear	Energy Transparency	Renewable Energy Commitment & Siting Policy	Energy Efficiency & Mitigation	Renewable Energy Deployment & Advocacy
Akamai	24%				A	C	A	C
Amazon.com	23%	21%	27%	26%	F	C	D	D
Apple	100%	0%	0	0	A	A	A	A
ebay	10%	51%	29%	9%	B	D	B	C
Facebook	49%	10%	25%	14%	A	A	A	B
Google	46%	15%	21%	12%	B	B	B	A
HP	22%	26%	41%	11%	C	D	B	C
IBM	24%	27%	30%	17%	B	B	B	C
Microsoft	29%	19%	30%	10%	C	C	C	C
ORACLE	17%	18%	50%	11%	D	F	D	D
Rackspace	25%	21%	33%	21%	C	B	B	C
Salesforce	23%	20%	25%	26%	A	B	C	C
YAHOO!	72%	6%	11%	8%	C	B	A	B

Colocation Companies

	Clean Energy Index	Natural Gas	Coal	Nuclear	Energy Transparency	Renewable Energy Commitment & Siting Policy	Energy Efficiency & Mitigation	Renewable Energy Deployment & Advocacy
Digital Realty	18%	30%	28%	20%	C	D	C	D
	6%	25%	32%	34%	D	F	D	F
	15%	29%	29%	20%	B	B	B	D
TelecityGroup	18%	27%	27%	15%	C	D	C	D

From: *Clicking Clean: a Guide to Building the Green Internet*. Greenpeace, May 2015.
http://www.greenpeace.org/usa/Global/usa/planet3/PDFs/2015ClickingClean.pdf

Interactive scorecard:
http://www.greenpeace.org/usa/global-warming/click-clean/

Your Online World: Green IRL, or #dirty?

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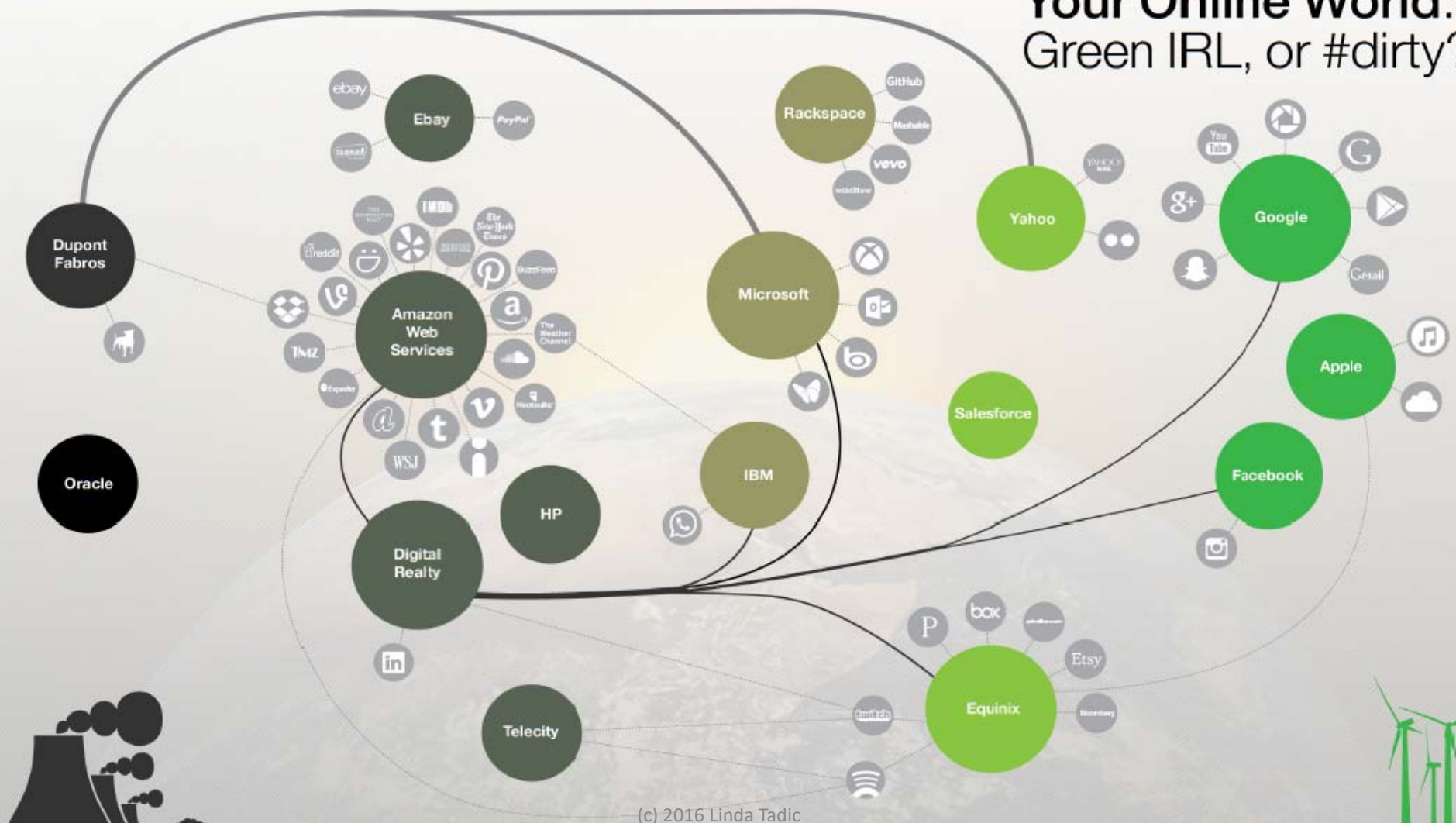
It's not too late to effect change

Los Angeles smoggy day, 1970s.

Cleaner air, healthier lungs

A study of more than 2,000 children in five Southern California cities found that their lung function improved as air pollution dropped.

As air pollution* declined...

1994: **28**
2011: **13**

'94 '96 '98 '00 '02 '04 '06 '08 '10

...the percentage of children with abnormally low lung function dropped.
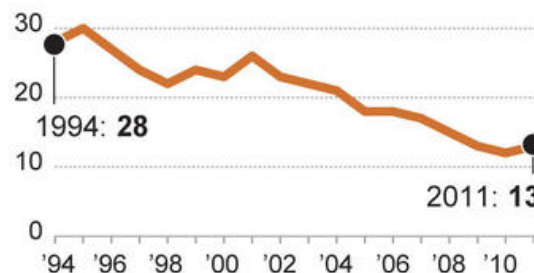
Group 1
'94-'98
7.9%

Group 2
'97-'01
6.3%

Group 3
'07-'11
3.6%

*Scale measures fine particle pollution/PM2.5 (annual average) in micrograms per cubic meter
Sources: Gauderman et al. 2015, New England Journal of Medicine; USC Children's Health Study

@latimesgraphics

Report released March 4, 2015

It's not too late to effect change

CREDIT: YOUTUBE.COM/SCREENSHOT

Over the weekend in China, 175 million people — more than the entire population of Bangladesh — watched a newly released in-depth and well-produced documentary about the country's debilitating smog problem. Produced by former Chinese news anchor and environmental reporter, Chai Jing, the 104-minute "Under the Dome" has caught the Chinese public at a moment of intense focus on the wide-ranging impacts of air pollution from coal-fired power plants and vehicle emissions.

Beijing smoggy day, 2013.
Photograph: HAP/Quirky China News / Rex Feat

Chai Jing's review: Under the Dome – Investigating China's Smog
柴静雾霾调查：穹顶之下　[March 1, 2015]
https://www.youtube.com/watch?v=T6X2uwlQGQM#t=207
http://thinkprogress.org/climate/2015/03/02/3628458/chinese-air
pollution-documentary-clears-the-haze/

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UN Climate Change Conference (Paris December 2015) (COP21)

https://www.climateinteractive.org/tools/scoreboard/

CLIMATEINTERACTIVE
scoreboard

Increase in Global Temperature by 2100

Where will proposals from the climate negotiations lead?

10
9
8 — **8.1** °F   **4.5** °C
7
6 — **6.3** °F   **3.5** °C
5
4
3 — **3.6** °F   **2.0** °C
2
1
0

business as usual
27 Oct '15 proposals
goals

°F

video ▶ ?

view in °C
view in °F

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2030   Ecuador: 10.2% below BAU by 2025   Eritrea: 39% below BAU
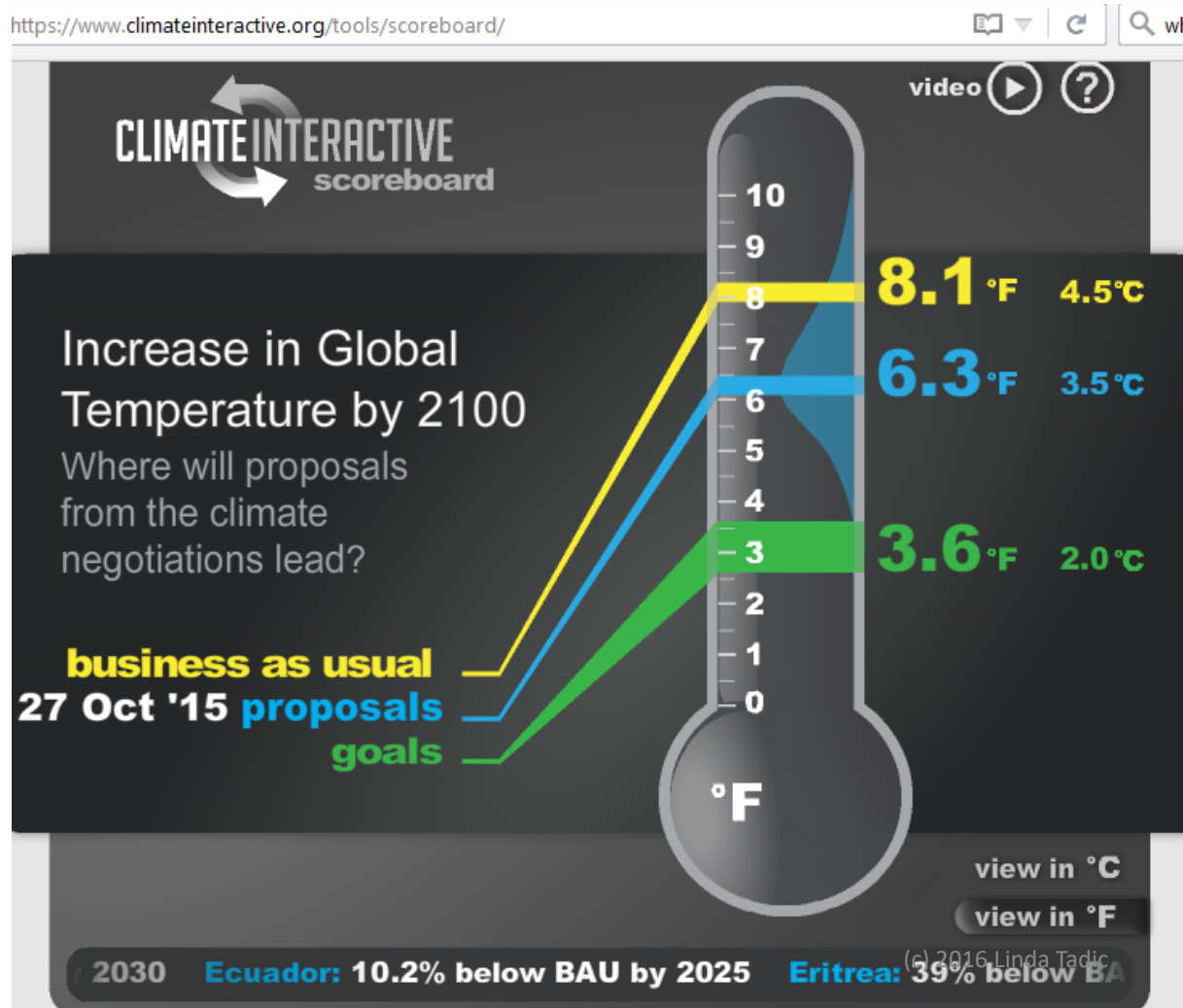
11/4/2016: Took effect. Ratified by 100 countries (55 were required). Even with US, China, & India, the signatories are 55% of world's polluters.

Countries proposed the percentage they'll lower GHG by 2030. Meeting week of 11/7/2016 to work out details.

UN Environment Program says world is on course to warm 2.9° C / 3.4° F by 2100 (Nov. 2016)

It's not enough.

More must be done.

Climate Interactive.
https://www.climateinteractive.org/

Impact of the Trump Administration

Paris Agreement. Any country wanting to withdraw must wait 4 years. But, he could ignore the accord. There are no legal consequences or fines by refusing to act.

Myron Ebell. Climate change denier, leading Trump's EPA transition team.

Trump. Wants to weaken (if not abolish) the EPA. Increase coal production. Climate change is a "hoax" perpetrated by the Chinese.

Change through lawsuits

June 2015:
The Hague District Court
ordered the Dutch government to cut
GHG emissions 25% by 2020 (currently
planned at 14-17%.)

http://www.theguardian.com/environment/2015/
jun/24/dutch-government-ordered-cut-carbon-emissi

http://www.huffingtonpost.com/2015/06/24/dutch-climate-change-case_n_7653050.html

Photo: Uberprutser

https://commons.wikimedia.org/wiki/File:Goliath_Poldermolen.jpg

Sued under tort law: a government has a duty to take care of its citizens.

900 people sued that they were being wrongfully harmed by their government's inaction.

Change through choices

- Individual
- ICT and related industries
- Archives

In 2014, **"for the first time since the invention of the steam engine, global emissions remained flat even as the global economy grew by about 3%."**

-- Elizabeth Kolbert. "The Weight of the world." *The New Yorker,* 24 Aug 2015

We know what we can do as individuals to lower our carbon "footprint"

Please Turn Lights Off When You Leave The Room

Protect the Environment for our Children

CARE FOR OUR PLANET: WASH LESS, WASH COLD, LINE DRY, DONATE OR RECYCLE

PRENEZ SOIN DE NOTRE PLANETE: LAVEZ MOINS, LAVEZ A FROID, LAISSEZ SECHER NATURELLEMENT, DONNEZ OU RECYCLEZ

CUIDA NUESTRO PLANETA: LAVA MENOS, LAVA EN FRIO, TIENDE LA ROPA, DONA O RECICLA.

CUIDE DO NOSSO LAVE EM ÁGUA FRI OU RECICLE.

RECYCLE

Paper or Plastic? NEITHER

ICT and related industries

- **Device** manufacturers developing products using less energy (ex.: helium-filled hard drives) and more recyclable parts (ex.: Fairphone)

- **Power sources**: trend to **renewables** (solar, air, hydro, biothermal): By 2030, 25% of global power sources will be renewables (Deutsche Bank). Germany is now 33%.

  Goals by 2030:

  > 50% in California (25% by 2020)
  >
  > 28% in US
  >
  > 40% in France (law passed July 2015)
  >
  > 20% in China
  >
  > 40% in India

- **Recycling materials**: plastic bottles already turned into carpet threads, fabrics, flooring, benches; increased R&D for recycling other plastics and heavy/rare earth metals.

"I want to be a bench. Recycle me."

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AV archives

What can AV archives do to mitigate their environmental impact AND improve their sustainability?

Staff actions

      Appraisal and retention policies

      Digitize at lower resolution formats

      Scheduling digital preservation processes

Technology choices

      Storage medium (spinning disks, digital tape)

      Decrease electricity use

      Consider storage medium recycling potential

      Power supply choices

      "Green" cloud and colocation vendors

Staff actions

- **Appraisal:** Retain and digitize fewer items
  - Not everything need be saved (impacts large archives more than small)
  - Apply appraisal and retention policies to born-digital content even before content is created.
  - Set policy for when to (responsibly) recycle dead media.

- **Digitize selected content at lower than optimal resolutions** to save storage space (and ongoing maintenance/energy use)
  - It's more important to save content at whatever format/resolution is feasible than wait to digitize at the highest level – and risk losing content in the meantime.

Staff actions

- **Digital preservation actions**
  - Schedule fixity checks every 6 months or even annually rather than monthly or quarterly. This will use less power.
  - Perform media-level fixity checks, verifying files only when the media check has an error. This will take less time (energy).
  - Store redundant copies on data tape offline (not attached to a power source)
  - Migrate to new media every two generations LTO (~ every 8-10 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.

Technology: Use less energy

Using less electricity helps the environment plus saves money.

1. Store large and infrequently accessed files offline on data tape.

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

Technology: Use less energy

If you have a server room on-site:

2. Set the room temperature higher: 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)

    Thermal Guidelines for Data Processing Environments. 3ʳᵈ ed. (2012)

Technology: Use less energy

3. Turn off inactive storage devices and machines.
4. Set servers to go to inactive mode when not in use.
5. Consolidate and virtualize several applications on one server.
   - This also results in fewer servers to replace/recycle.
6. If you have the budget, use helium-filled HDDs or SSDs
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.

Technology: Environmental planning

1. Purchase clean energy where possible, not coal-generated.

2. Purchase hardware that is energy efficient.

3. If recycle by re-use, use vendors who don't ship overseas.

4. 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.

Conclusion

Reports show there is already a decrease in carbon emissions in the last few years due to governments, corporations, companies, and individuals changing behaviors and taking positive actions.

In being mindful of its impact on the environment, an archive improves its own sustainability as well as the planet's.
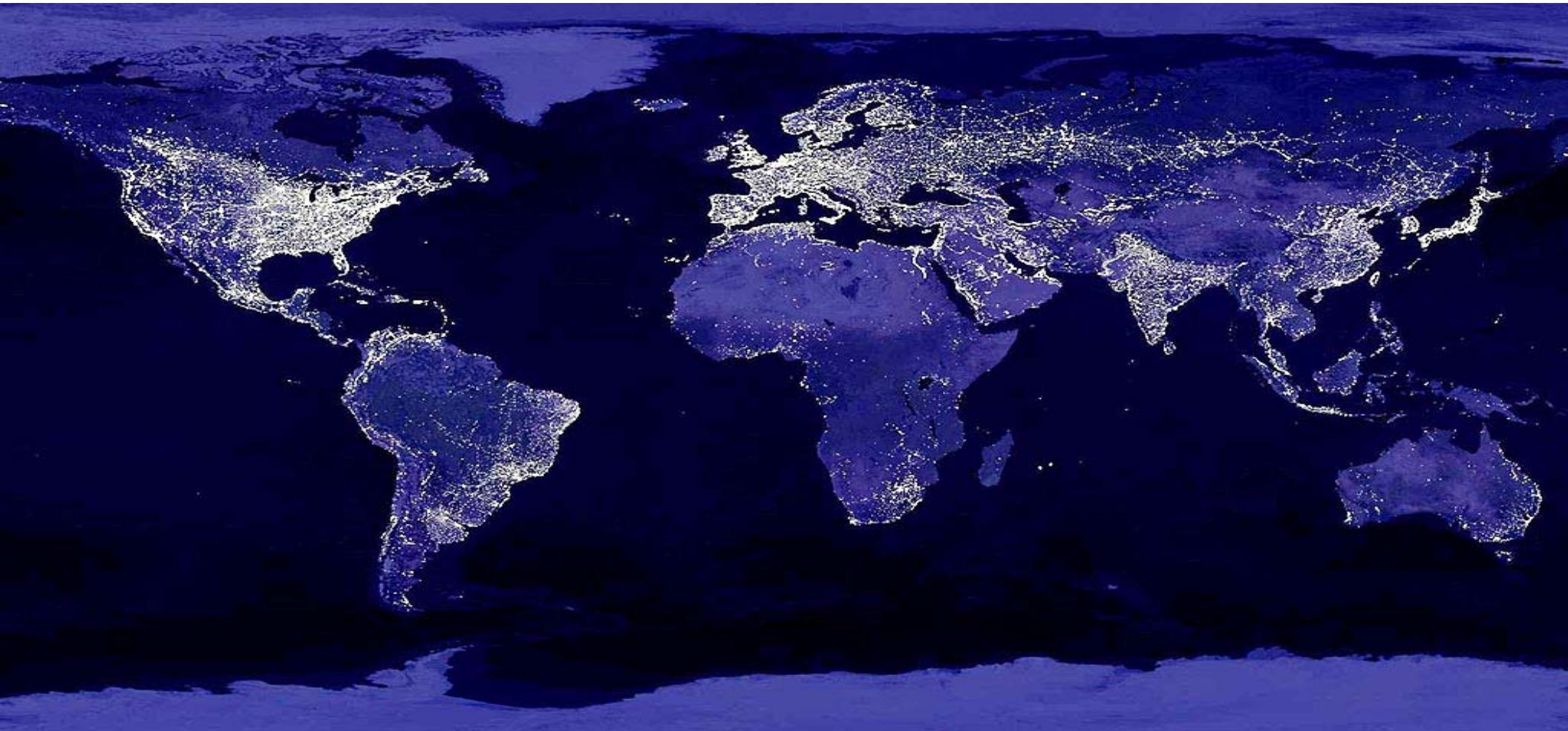
Photo: NASA

Thank you.   Linda Tadic   ltadic@digitalbedrock.com

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