Externalities of the Digital Library

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Abstract

Digital libraries offer unparalleled access to information in comparison to older analog information systems, which has prompted widespread prognostication about the imminent demise of the physical library. Yet, without a cheap, abundant electricity supply, digital access to information would not exist. This article explores the hidden implications of ecological overshoot for digital libraries that are beginning to appear in the form of climate change, failing electricity grids, power outages, shortages in hydrocarbon energy sources, resource wars, and the specter of financial collapse. Although most of the analysis concerns North America, references to other regions are given. The author concludes with a call towards the development of "green" librarianship to mitigate the dire consequences that may result from future energy shortages.

"It takes electrons to move bits. The digital economy, which most everyone loves, is completely dependent on the big central power plant, which most everyone hates. This is, or ought to be, an inconvenient fact for many politicians."

Peter Huber, *The Wall Street Journal*, September 6, 2000[1]

At the dawn of the Digital Age, few library and information specialists imagined the revolutionary changes that would occur when computers entered libraries and, subsequently, when libraries entered computers. On the surface, it appears that a majority of librarians view the automation and digitization of libraries as positive developments for information retrieval, access and availability, storage and preservation, resource sharing and labor costs. Yet hidden from such progress is a host of negative externalities that remains absent in the discourse on digital libraries. The concept of digital or virtual libraries is also "virtual" in the scholarly literature as there exist few examples of scholarship that recognize its physical, material basis.[2] The continuing digitization of traditional, analog resources has a very real ecological impact. Proposed here, as a starting point for a more complete discussion of the topic, is a definition of “digital library” that places digitization efforts in a larger ecological context.

Defining "Digital Library"

One of the earliest examples of a definition of “digital library” comes from A. J. Harley’s discussion of the related term “virtual library.” Harley, like other computer information specialists employed in the library environment, envisioned what the library could become through the integration of computer technology. Harley’s definition was indeed prophetic:

> The 'virtual library' is one where the user has the illusion of access to a much larger collection of information than is really present, immediately or simultaneously. In the ultimate virtual library, he has access to universal knowledge without delay, at his desk.[3]

Reitz’s definition represents what the digital library had become two decades after Harley's initial imaginings, highlighting several key concepts such as the reliance on digital collections and electronic resource sharing within physical libraries; local versus remote access; the evolution of digitization; and the predominance of computerized access to information:

> A library in which a significant proportion of the resources are available in machine-readable format (as opposed to print or microform), accessible by means of computers. The digital content may be locally held or accessed remotely via computer networks. In libraries, the process of digitization began with the catalog, moved to periodical indexes and abstracting services, then to periodicals and large reference works, and finally to book publishing.[4]

The question of community arises in several definitions and discussions of the digital library.[5] Many of these definitions argue that digital libraries are more than just equipment and digitized data but are fundamentally comprised of "information communities," i.e., human beings that communicate through computerized information flows. Thus, the image of digital libraries portrayed in these works calls to mind the cyborgs of Star Trek, the Borg Collective—a group of sentient beings who are interconnected by organic and inorganic materials through a vast wireless information network that makes their assimilation of other sentient, organic beings unavoidable. The Borg's infamous phrase "resistance is futile" is eerily apt for describing the rapid digitization and automation of libraries of the past ten years: the contemporary librarian would seem to be at the mercy of a credo to digitize and share the library's collection or be vanquished.

One particularly eloquent statement about the human, communal dimension of digital libraries can be found in David Robins' article, "From Virtual Libraries to Digital Libraries: The Role of Digital Libraries in Information Communities":

> Digital Libraries, like physical libraries, are not about the technology that supports them (although they would be useless without it), and they are not about metadata standards yet to be developed, although without records and pointers, digital libraries would suffer the maladies of full-text searching...Digital libraries are not about data structures and electronic representations. Digital libraries are not about the interfaces that make their use more or less effective...Digital libraries, like physical libraries, are about communities: interests, behaviors, goals, and recognizable traits that belong to groups of people.[6]

Perhaps the broadest description of the digital library comes from The Joint Conference on Digital Libraries (JCDL) 2006 conference announcement. This description gives both static and processual properties of digital libraries. It appears that the JCDL's inclusivity is motivated in part by the recognition of the wide-reaching effects of the digital library in addition to the goal of attracting a variety of conference attendees:

> JCDL encompasses the many meanings of the term "digital libraries," including (but not limited to) new forms of information institutions; operational information systems with all manner of digital content; new means of selecting, collecting, organizing, and distributing digital content; digital preservation and archiving; and theoretical models of information media, including document genres and electronic publishing.[7]

An Ecological Definition of “Digital Library”

Ecology is the study of the interaction of living organisms with their environment. In this paper, the adjective “ecological” is used to signify a broad look at the totality of digital libraries, from its social, cultural, and political dimensions to its physical status as a phenomenon determined by biological and geological factors. While the preceding definitions cover many aspects of digital libraries, none of them highlight its fundamental physical, material requirement: electricity (i.e. electric power). Therefore, I offer my definition as an indirect critique of the four perspectives listed above:

> A digital library consists of inter-related communities of information seekers and providers who interact with and transform the information flows of computer networks of magnetically stored data, accessed primarily through hydrocarbon sources of energy.

Digital libraries are wholly dependent on a cheap, abundant supply of electricity. Yet this basic fact is absent in the discourse on digital libraries. Herein lies a set of tremendous problems that are beginning to emerge as what Kunstler[8] calls "converging catastrophes": *externalities* of the digital library.

The Externalities of the Digital Library

Economists use the term *externality* to refer to the unintended costs or benefits of the production and consumption of material goods. While most discussions of externalities focus on the negative side effects of economic activity—particularly pollution from industrial production—some externalities can be considered positive when they benefit the common good. The following is a definition of the conventional usage of the term from the *The Economist* (2006):

> An economic side-effect. Externalities are costs or benefits arising from an economic activity that affect somebody other than the people engaged in the economic activity and are not reflected fully in prices. For instance, smoke pumped out by a factory may impose clean-up costs on nearby residents; bees kept to produce honey may pollinate plants belonging to a nearby farmer, thus boosting his crop.[9]

The following discussion analyzes the negative impact that digital libraries have on our environment and how the conversion of analog documents into digital documents is likely to cause a crisis of access to information when faced with a failing energy infrastructure and global decline of hydrocarbon fuel production.

Externality #1: Carbon Dioxide Emission

Carbon dioxide (CO2) emissions are the most visible externality of the digital library.

Digital libraries are fundamentally electronic in nature. Without electricity, the contents of the digital library cannot be stored and accessed. Thus, we must ask ourselves: where does our electricity come from? According to the Energy Information Administration[10] over half of the electric power supply in the United States in 2004 was produced from coal (52 %), followed by nuclear energy (21%), natural gas (16%), hydroelectric energy (7%), and geothermal and other (1%). Thus, it is clearly evident that the vast majority of our electric power is produced from coal, which is one of the most polluting, environmentally destructive hydrocarbon fuels.[11]

When we burn hydrocarbon sources of energy we release carbon dioxide into the atmosphere. Scientists have reached a consensus concerning the human role in climate change.[12] Clean coal technology is not as "clean" as we think.[13] Such technology involves a process known as "carbon dioxide sequestration" that involves injecting emissions into the ground instead of into the air.[14] While many proponents of coal production quickly point toward so-called "clean coal technologies," such a discursive maneuver obfuscates the reality of how the coal industry actually conducts business.[15] So-called clean coal technologies are in their infancy and require enormous financial capital to develop.[16]

Digital libraries are fully complicit in filling the atmosphere with carbon dioxide emissions. While debate surrounds the ecological footprint of digital and print information sources, the sparse research on this topic has focused more on the life-cycle analyses of one medium versus another and less on their environmental impact.

A study by Zurkich and Reichart[17] compared analog and digital telecommunication services and concluded among other things that "email is more damaging to the environment than a letter sent with the postal service." A related study by Gard and Keoleian[18] that was funded by AT&T found that the factors that determine the "energy performance" of print and electronic media are too complex for simple conclusions and instead are "[dependent] on the aggregate behavior of individual users."

One factor that the latter study did not consider was the broader energy infrastructure of electronic journals: burgeoning server farms[19] and the air conditioning required to keep them cool.[20] When we run our computers 24/7/365, increase broadband internet access, install wireless networks, and increasingly access our information needs electronically, we demand increasing amounts of electricity not just from the specific equipment of the information highway but from the infrastructure that supports it. The Internet servers of today outstrip the power consumption of those of the past not due to lack of energy efficiency but to the sheer number of servers that are needed to meet demand. This has caused some computer industry analysts to cast doubt upon the long-term economic viability of these server farms.[21] Furthermore, the high temperatures of these server farms are threatened by the record hot temperatures now common during the summer season in North

America. This issue received much attention in July 2006 when the popular social networking site MySpace.com shut down due to the overheating of their servers.[22] Far from being a marginal issue, overheating was also the central topic of a major conference of computer industry executives entitled "The Invisible Crisis of the Data Center."[23]

The shift towards digital libraries is part of the soaring demand for electricity in recent years that is expected to continue to rise in the foreseeable future.[24] This fact was mentioned six years ago to a select audience by Vice President Richard Cheney in Toronto, Canada, 2001:

> We all speak of the new economy and its marvels, sometimes forgetting that it all runs on electric power. An overall demand for electric power is expected to rise by 43 percent over the next 20 years...just meeting projected demand will require between 1,300 and 1,900 new power plants. The low estimate is 1,300 new plants; the high estimate, 1,900 new plants. That averages out to more than one new power plant per week every week for the next 20 years.[25]

Externality #2: The Future of North American Coal and Natural Gas Reserves

The depletion of hydrocarbon sources for electricity production poses an existential threat to digital libraries.

Several issues confront the future supply of coal and natural gas for electricity production in North America. First and foremost: the stated reserves of coal and natural gas. While the coal industry claims that the United States is the "Saudi Arabia of coal." such an assertion is based on imprecise data that was produced from research conducted by the U.S. Geological Survey (USGS) over fifty years ago.[26] Recent research on and publication about available coal reserves has presented a much starker picture than what the industry would like to discuss.[27] Even if an adequate supply of coal were to continue for decades to come, another issue is the shipping and refining capacity of coal production. At present, coal shortages are now appearing simply due to the inability to extract, produce, and ship enough coal to meet the ever-increasing demand for electricity.[28]

The grim state of the United States' natural gas reserves has prompted energy experts to predict dire consequences in the near future.[29] Many of the electrical power plants built in the past two decades were designed to produce from natural gas instead of coal due to the polluting externalities of coal production. The fact that U.S. natural gas production peaked in 2001 has resulted in the current importation of 60% of Canada's natural gas production.[30] Some experts predicted significant blackouts during the winter of 2006 in the Northeastern U.S. due to natural gas shortages; fortunately, the record warm weather saved Northeastern communities from potential power failures.[31]

One solution to natural gas shortages is legislation to increase importation of Liquefied Natural Gas (LNG) and build new LNG terminals.[32] However, coastal communities know of the great danger that they pose as a safety risk[33] and easy target for sabotage.[34] Furthermore, the remaining abundant natural gas reserves are located where the oil reserves are: the Middle East and Russia.[35]

Externality #3: A Failing National Grid

Power outages and "brownouts" pose a problem for digital libraries.

Should there be adequate energy resources for electricity production in the near future; the lack of capacity to transmit electrical power is a vexing problem at present. In their National Transmission Grid Study,[36] The U.S. Department of Energy observed that:

> There is growing evidence that the U.S. transmission system is in urgent need of modernization. The system has become congested because growth in electricity demand and investment in new generation facilities have not been matched by investment in new transmission facilities. Transmission problems have been compounded by the incomplete transition to fair and efficient competitive wholesale electricity markets. Because the existing transmission system was not designed to meet present demand, daily transmission constraints or "bottlenecks" increase electricity costs to consumers and increase the risk of blackouts.

Similar warnings about the underinvestment in adequate energy infrastructures have been issued by a number of highly reputable energy analysts and government institutions.[37] Several major urban centers that are accustomed to uninterrupted supplies of electricity are beginning to experience blackouts and "brownouts" or are being warned of such outages.[38]

In July 2006, the United States experienced a significantly high number of power outages—

including major blackouts in Queens, NY, and California—because of failures in the electrical grid from spikes in demand due to heat waves and severe storms.[39] The following summer (2007) witnessed the same high temperatures and flooding.[40] Nor does the forecast augur well for many international urban centers such as London, Cape Town, and Toronto.[41] Developing nations have seen persistent, major power disruptions which have in some cases resulted in the eruption of protests and riots against the power generating facilities themselves.[42]

Externality #4: Peak Oil and Economic Collapse

Digital libraries are part of a larger economic system that requires access to and consumption of cheap and ever-increasing supplies of extracted and refined oil and natural gas.

The imminent peak in global oil and natural gas production, collectively known as peak oil, has received significant media coverage both pro and con;[43] however, this topic of grave importance has yet to receive public recognition from the President of the United States.[44] Nevertheless, a peak in oil and natural gas production and not merely their total depletion poses challenges of untold proportions.[45] Oil production in the United States peaked in 1970, an event predicted in 1956 by the

prescient geologist M. King Hubbert, who at one time worked for Shell Oil. The United States now imports roughly 70% of its current oil consumption and now finds itself mired in multiple resource wars to ensure “energy security.” A significant number of geologists and energy industry analysts have since applied the Hubbert peak theory to global energy reserves and some have presented convincing evidence that the global peak has been reached.[46] Non-OPEC production peaked in May 2005, while OPEC reached a plateau in September.[47] Despite dramatic fluctuations in the price of oil, OPEC oil production continues to experience declines by the thousands of barrels.[48]

The implications of the peak in global oil and natural gas production should not be underestimated. Declining oil and natural gas reserves threaten almost everything upon which our current industrial, electromagnetic societies function. When a declining energy supply cannot meet increasing demand, energy costs will inexorably rise to the point of bankrupting individuals and institutions, including energy companies. Debt-ridden economies are dependent on economic growth; however, without cheap, abundant sources of energy—especially oil—growth is not possible. The relationship between peak oil and economic collapse is simple: the current capitalist financial system, which creates wealth through the issue of debt by private banks, is a system of confidence that requires ever-expanding economic growth to pay off past, current, and future debt. Economic growth requires an ever-expanding energy supply; however, when the financial system faces an energy descent, growth will not be possible. According to peak oil theory, the prime energy of the world—oil—will begin a gradual decline, causing a halt in economic growth and crushing the system of confidence upon which all debt is issued. Thus, many peak oil theorists believe that the world's interdependent economies face a second Great Depression of possibly greater severity than the first.[49]

This leads to an issue of great concern among many librarians: the Digital Divide.

Externality #5: Unaffordable Energy and the Digital Divide 2.0

Energy issues are virtually absent in discussions of the Digital Divide, but will become unavoidable when energy reaches unaffordable levels for a majority of home computer users.

Eschewing the possibility of a sudden collapse of society,[50] increasing energy costs due to resource depletion accompanied by financial collapse will cause many of the "haves" who presently possess access to computers to become "have-nots" due to deepening economic recessions or possibly a depression that equals or surpasses that of 1929. Who will have access to digital libraries and computerized information systems when the costs of accessing such systems will be beyond the financial reach of most "information" community members? Should public libraries manage to keep their computer facilities afloat, will there be even more demand for computer and Internet access from the have-nots?

In a recent study by the Pew Internet & American Life Project[51] entitled “The Future of the Internet” virtually no reference was made to energy issues in their discussion of the Digital Divide other than the plan to provide $100 wind-up laptops for the impoverished children of developing nations. It is quite possible that so-called "developed nations" will want those laptops for themselves in a scenario of economic collapse and unaffordable energy.

The Assumption of a Techno-fix

North American society and culture is mired in a pervasive, unexamined assumption that technological solutions (“techno-fix”) will be implemented quickly enough to ease the impact that declining hydrocarbon resources will have on the global economy.[52]The problem with the techno-fix approach is our desire to maintain the current levels of energy consumption that mark energy-intensive lifestyles, especially as found in North America. Instead of advocating the “power down” approach of energy conservation,[53] we believe, rather naively, that technology will come to the rescue because it always has since the beginning of the Industrial Revolution. A sober review of the prospects of alternative energy reveals that no quick techno-fix is on the horizon.

Wind and photovoltaic technologies are unlikely to be mass produced on the scale needed to match even a small portion of the energy that is currently derived from hydrocarbon sources. Furthermore, the depletion of oil and natural gas reduces the ability to produce wind and photovoltaic technologies, as the manufacturers of wind turbines and solar panels themselves do not use those technologies to produce their products. The same can be said for just about any “alternative” energy source: they require an underlying oil and natural gas industrial infrastructure.[54]

Nuclear power is often considered, even by many environmentalists, to be a non-polluting

energy source, yet the facts counter such a claim. There still remains no environmentally friendly solution for dealing with nuclear waste.[55] Furthermore, there is discussion of shortages in the stock fuels for nuclear power such as uranium.[56] The high-tech “breeder” nuclear power plants comprise a small percentage of the current total plants and have not proven to be the panacea that they originally promised.[57]

The so called “unconventional” sources of oil such as the tar sands and oil shale of Canada are much touted by the mainstream press as an energy solution, yet absent in such discourse are massive environmental problems whose publicity would not benefit the producers of unconventional oil. Tar sands and oil shale require enormous amounts of fresh water and natural gas to produce,[58] and the environmental destruction from unconventional oil production is massive.[59] In addition, the energy derived from the use of energy to create it is quite marginal and will become unsustainable once conventional oil and natural gas reserves begin to decline rapidly.[60]

Another source of energy touted in mainstream news sources is the great promise of biofuels, especially ethanol. While the production of ethanol benefits agribusiness and corn farmers in particular, what is not considered in such an “alternative fuel” is the enormous amount of energy that is required to produce the feedstock, namely petroleum-based farming. Agribusiness is one of the most energy-intensive methods of farming, requiring fertilizers made from natural gas and pesticides made from oil. Furthermore, the low energy density of biofuels cannot possibly replace the high energy density of hydrocarbon fossil fuels. Several planets of corn would be needed to match the current level of energy provided by oil and natural gas.[61]

One often hears of the future of a “hydrogen economy,” yet many people fail to realize that hydrogen is not a form of energy but rather a carrier of energy.[62] Like ethanol, the current state-of-the-art technology for hydrogen production takes more energy to produce than it yields.[63] Research and development of hydrogen technology have progressed for decades with no economically viable solutions reached to date.

Conclusion: Toward Green Librarianship

Digital technologies have introduced unprecedented temporal and spatial transformations of culture and society that have, among other things, prompted many to talk and write of the end of the *physical* library and other analog information systems.[64] Such discourse seems to be based on the assumption that technology will inexorably advance towards a civilization of automated convenience akin to the 1960s animated television series *The Jetsons*. Hidden in such an assumption is a grave error that will be realized much sooner than later: the conflation of energy with technology. The digital technology that we normatively speak of is *electronic* and therefore brought to life primarily through the extraction and processing of hydrocarbon sources of energy such as coal and natural gas. While this simple observation may seem obvious enough, it recedes into our subconscious until a power outage occurs and we are suddenly reminded of our precarious, near-total reliance on electrical power as the foundation of our present civilization.

The urgent task at hand is for digital librarians, archivists, and library IT specialists to become aware of and plan for the global energy crisis that is starting to unfold. Given the magnitude of the challenges, is it realistic to talk of “solutions” to these problems? One widely read blogger on energy issues has aptly used the term “responses” for understanding and advocating a more realistic approach to these deeply complex issues.[65] Thus, what can we possibly do to prepare for and respond to the challenges that we will face from climate change, failing electricity grids, hydrocarbon fuel depletion, and financial collapse? Offered below are just a few ideas for designing and redesigning libraries and information systems for a finite ecological system.

Energy literacy campaigns

The first step in finding a solution to these challenges is to admit to having a problem. Librarians should develop energy literacy campaigns to make others aware of the serious issues that confront us in the near and distant future. Despite the essential role that electricity plays in our work, how many in the library and information science field know how it is produced? What is the electricity consumption of our library's computers or the air conditioning for preserving our digital and analog collections? Libraries should make energy literacy campaigns a top priority among their own staff as well as the general public.

Energy conservation and green architecture

Related to energy literacy campaigns are the simple things that we can do to reduce our ecological footprint at our own work places. We can increase energy efficiency through personal work habits such as turning off our computer work stations and other electrical equipment when the library is closed. Longer range plans might include the construction of off-grid electricity sources and modifying existing buildings to include passive solar heating and natural lighting. Architectural planning for new library buildings should follow recent examples of “green buildings”[66] and LEED green building rating system.[67] We might consider making new programs in or increasing funding for book conservation and repair as a means of safeguarding our print collections.

Relocalization

Librarians need to "relocalize" the information systems of their communities in preparation for increasing power failures that will result in the lack of access to networked, digital information from distant nodes of the Internet. The increasing lack of a seamless Internet will require that we not only restock the library's print resources but also develop an information base of key institutions, groups, and individuals of a library's community that is stored locally on a variety of computer media or developed as a continually updated print resource. Librarians and their professional organizations should develop access to information as an essential ingredient of the Post Carbon Institute's vision of *relocalization*:

> Relocalization is a strategy to build societies based on the local production of food, energy and goods, and the local development of currency, governance and culture. The main goals of Relocalization are to increase community energy security, to strengthen local economies, and to dramatically improve environmental conditions and social equity... Our dependence on cheap non-renewable fossil fuel energy has produced climate change, the erosion of community, wars for oil-rich land and the instability of the global economic system.[68]

Increase funding for disaster and risk management

Libraries need to devote a significant portion of their operating budgets to disaster and risk management. What would physical and digital libraries do in the case of lengthy power outages? The major blackout on August 14, 2003 caused massive economic loss.[69] One study found that "one third of businesses surveyed have no risk management or disaster recovery plans in place."[70] A survey of national libraries by Varlamoff and Plassard[71] found that only 53% of libraries surveyed had a working disaster plan in place.

Culture Change

What is truly the need of the day is large-scale culture change in which individuals, institutions, and societies recognize our current predicament of "ecological overshoot" and begin an immediate program of deconsumption[72] and ecological sustainability.[73] Certainly, high-tech solutions should not be rejected; however, we need to look honestly at the ecological footprint of our own lifestyles and see what can also be done without cutting-edge technology. In short, we need to recognize the finitude of the earth.

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