

ENV 261F, Fall 2018

Is the Internet Green?

Miriam Diamond
Dept. of Earth Sciences
Office: 22 Russell St. rm 3141
Phone: 416 978-1586
E-mail: miriam.diamond@utoronto.ca
Office hours: Wednesday 2-4pm (best to make an appointment)

Class Meetings: Tuesday 2-4 pm MP134

Tutorials: Tuesdays 4-5pm MP 118; Thursdays 4-5pm BA 3116

Teaching Assistant: Milan Illycky

Course information is posted on Quercus.

Course theme:

Every year instructors at the University of Toronto are asked if your course is “green” – “where steps have been taken to reduce the use of paper”. The implicit assumption here is that using computer technology to distribute and gather course materials and assignments has a lower environmental impact than using paper. Is this a “good” assumption? What are the environmental benefits to using computer technology and the Internet rather than paper to exchange information? We will probe this question and beyond to look at the Internet and information and communication technologies (ICT) through the lens of environmental sustainability.

And why should we dedicate a course to examining the environmental sustainability of the Internet? It is hard to imagine a world without ICT. Estimates suggest that over half of the world’s population is online. In only a few decades, the Internet has come to pervade virtually all aspects of our lives from education to how we build and maintain friendships, to how we shop, to the way we think, solve problems and retrieve information. Although we are very familiar with and extensively use the Internet, few of us understand the inner workings of the technology. Further, the Internet has many unintended consequences at personal, societal, and environmental levels, whether it is cloud computing or the materials from which your cell phone is made.

Our task is to think critically about the choices (and lack of choices) that this new technology brings us, and to explore and act on the intended and unintended consequences and responsibilities that come with ICT. This course intends to help us make informed choices and be active participants rather than passive consumers of ICT.

Course objectives:

This course examines and debates the environmental sustainability of ICT, including intended and unintended consequences, using lectures, in-class activities and real-world examples that foster critical thinking and problem solving. The course will introduce you to disciplinary and interdisciplinary modes of inquiry and engagement.

What you will learn in the course:

- How to probe the breadth, depth and interconnectedness of a system as complex as the Internet; how complex phenomena defy simple explanations, and why it’s important to think and solve problems with the help of multiple disciplines.
- How to think critically and use tools for creative and effective problem solving as individuals and in groups.
- To improve your scientific literacy and communication skills, through: 1) a deeper understanding of how ICT works; 2) how to assess environmental benefits and costs of ICT; and 3) how to clearly communicate your ideas using a variety of forms.

Course Evaluation:

Assignment 1: Measure the carbon footprint of your ICT devices	Due October 16; final Oct 23	25%
Assignment 2: Unintended consequences of ICT: the problem and solutions. Group project.	Due November 20, final Nov 27	30%
Tutorial participation (five over the term)		5%
Reading summaries (five over the term)	Throughout the term	10%
Final Exam	Final exam period	30%

Coursework Assignments (55% overall): Each assignment will be discussed in class and then completed outside of class time. You will have the opportunity to improve each assignment through a peer review process.

- Assignment 1 is completed individually. It involves tallying ICT devices owned and used by yourself and your family. You will then calculate the embodied carbon emissions contained in those devices.
- Assignment 2 is conducted in groups of 2-4 students. You will explore unintended environmental consequences of one aspect of ICT and develop options and a plan for averting or minimizing those consequences. Examples include the environmental sustainability of the use of conflict minerals in ICT devices and the social sustainability of mass production of ICT devices.

Marking rubrics for each assignment will be available one week before the submission date. Some of the criteria included in the rubrics include depth of critical analysis, coverage of the literature, coherence and comprehensibility, and presentation.

The first version of your assignment is due by the beginning of class on the first due date by 2:10pm. Submit through Quercus and bring a hard copy to class. You will peer review one other student’s assignment in tutorial. Your final assignment is due in hard copy on the last due date - at the beginning of class by 2:10pm.

Final, hard copies of late assignments must be submitted to the drop box outside the School of the Environment’s administrative offices ES1016V. This is just inside and to the right of the east entrance to

the 33 Willcocks Street wing of Earth Sciences – near the large Forestry banner on the east wall of the building.

All assignments should include the following information:

- Your name
- Title of assignment
- Course title and number
- Name of Professor and TA
- Double or 1.5 line spacing using 12 point type in black ink with 2.5 cm (1 inch) margins
- Include page numbers

Tutorials. Five tutorials over the term are aimed at helping you to improve your research and communication skills. Each assignment will be discussed in tutorial and your penultimate version will be peer reviewed. Attendance at each tutorial is worth 0.5% of your total mark and a further 0.5% if you participate. Thus, attending and participating in tutorials can give you 5% of your total mark. Each week a tutorial is held is indicated below by the underlining of the date.

Reading summaries. You will submit a summary of five required readings of your choice over the duration of the term. Summaries of websites or videos are not eligible. The summary should be 1 page in length or 500 words total. The summary should be written in prose and not point form. Each summary is worth a maximum of 2% for a total of 10%. A summary for a reading is due before it is discussed in class. Submit through Quercus. You are responsible for keeping track of the number of reading summaries you submit.

Final exam. A two hour final exam worth a maximum of 30% will be held during the exam period at the end of term. The exam will be a combination of short answer and a few long answer questions based on lectures, readings and assignments. You may bring a one page (double sided) summary of information to the exam.

Class Policies:

Late Penalty for assignments: A lowering of the grade by one increment per day, unless accompanied by documentation (see <http://www.illnessverification.utoronto.ca>), e.g., from B+ to B for 1 day late, B+ to B- for 2 days late including weekends (one day of the weekend is counted). The note must include the dates of absence. Late assignments will not be accepted one week past the due date even if accompanied by a certificate unless you have obtained prior agreement from the instructor.

Requests to re-mark your assignment must be submitted in writing to Prof. Diamond and clearly state the reason for your request. Prof. Diamond will respond within a week as to whether your assignment will be remarked. Your assignment will be remarked by our TA.

You can expect a response to a post on Quercus within 24 hours on weekdays and 48 hours on weekends. Do not expect responses to questions about assignments within 24 hours of the due date.

Academic Integrity:

Very few of us have truly original ideas but rather we almost always build on the ideas and information provided by others. We need to re-emphasize that plagiarism — representing someone else's words as your own or submitting work that you have previously submitted for marks in another class or program — is a serious offence. Assignments, reading summaries and exams are reviewed for evidence of these infractions. Penalties for these offences can be severe and can be recorded on your transcript.

- Trust your own ability to think and write and make use of the resources available at U of T that can help you do so (e.g. professors, TAs, writing centres). See the U of T writing website, especially the “How Not To Plagiarize” document at <http://advice.writing.utoronto.ca/using-sources/how-not-to-plagiarize/>. More information is available at: <http://www.artsci.utoronto.ca/osai>

The following is a list of examples (not complete) of what constitutes an academic offence:

- Using someone else’s ideas or words without appropriate acknowledgement.
- Copying material word-for-word from a source (including lecture and study group notes) and not placing the words within quotation marks and not citing the author/source.
- Submitting your own work in more than one course without the permission of the instructor.
- Making up sources or facts, including references to sources that you did not use.
- Obtaining or providing unauthorized assistance on any assignment including:
 - Working in groups on assignments that are supposed to be individual work
 - Having someone rewrite or add material to your work while “editing”.
 - Lending your work to a classmate who submits it as his/her own without your permission.

On tests and exams:

- Using or possessing any unauthorized aid, including a cell phone
- Looking at someone else’s answers
- Letting someone else look at your answers
- Copying material word-for-word from a source (including lecture and study group notes) and not placing the words within quotation marks and not citing the author/source.
- Misrepresenting your identity
- Submitting an altered test for re-grading
- AND FOR THIS COURSE, submitting for credit a definition taken verbatim from another source without attribution

Misrepresentation:

- Falsifying or altering any documentation required by the University, including doctor’s notes
- Falsifying institutional documents or grades

Participation:

Students are expected to attend every class having prepared their responses to the required readings or videos, etc., and to participate fully in the discussion through both attentive listening and speaking. Research shows that you improve your concentration and recall when you take notes longhand and when you “unplug” from the Internet during class. So, during class please hide your cell phone and minimize your use of computers unless it’s necessary.

Accommodation:

The University of Toronto is committed to accessibility. If you require accommodations for a disability, or have any accessibility concerns about the course, the classroom or course materials, please contact Accessibility Services as soon as possible: accessibility.services@utoronto.ca or <http://studentlife.utoronto.ca/accessibility>

Reading/Viewing/Listening hints:

As you read, listen, and/or watch, take notes on the following:

- 1) **Identify the key terms in the reading.** Think about how the author(s) defines these terms and uses them in the broader argument.
- 2) **Note key concepts that relate to other readings/lectures** in the course and that help you to understand the main themes in the course and their interrelationships, i.e., build bridges between the readings and lectures.
- 3) **Note methods used** to investigate the topic or solve the problem. How could you use this method?
- 4) **Write down any questions** that arise when in lecture and reading (no question is stupid!).
- 5) **Look up words/concepts** in the reading that you do not understand. Reading with a dictionary at your side is the best way to expand your vocabulary!
- 6) **Explore the context for the reading.** As you know, the Internet is moving fast! How recently was it published? At what stage in the development of the Internet was it written? What type of publication did it appear in? How does it relate to other readings you have met?

Remember, when writing down a quote, **always put quotation marks around the author's words** and note the page number from which you are quoting. This will provide you with a good basis of quotes for later writing assignments, and will help you to develop responsible practices of note-taking in line with the requirements of academic integrity.

LECTURE SCHEDULE AND READINGS

1) Sept. 11: Why is this course about the Internet and why the question “is it green”?

We will introduce the professors, the course themes, and the students to each other, through a combination of in-class activities and short lectures.

Required Reading:

- Naughton, J. The Internet: Everything You Ever Need to Know, The Observer, Sunday June 20, 2010. <http://www.theguardian.com/technology/2010/jun/20/internet-everything-need-to-know>
- “Tsunami of data” could consume one fifth of global electricity by 2025. <https://www.theguardian.com/environment/2017/dec/11/tsunami-of-data-could-consume-fifth-global-electricity-by-2025>

Recommended Sources:

- Can the digital revolution be environmentally sustainable? <https://www.theguardian.com/global/blog/2015/nov/13/digital-revolution-environmental-sustainable>
- Watch: Manuel Lima on the Power of Networks: <https://www.youtube.com/watch?v=nJmGrNdJ5Gw>
<https://www.youtube.com/watch?v=nJmGrNdJ5Gw>

2) Sept 18: Environmental problem solving, systems thinking and the Internet.

Systems thinking is a method of understanding and thus problem solving for complex systems and processes of change within them. We need to adopt a systems thinking approach to explore the question “is the Internet green” because of the complexity of system (the Internet and society). Life cycle assessment is one tool that takes a systems thinking approach. We delve deeper into systems thinking approaches and explore some properties of systems that cannot be understood by studying parts of a system in isolation (e.g. exponential growth, feedback loops, etc).

Required Reading:

- Meadows, D. 2008. Chapters 1 and 2. *Thinking In Systems: A Primer*. Chelsea Green Publishing. Read until the car sales example (“A systems with delays – Business Inventory”)

Recommended Reading:

- Elia, G., Margherita, A. 2018. Can we solve wicked problems? A conceptual framework and a collective intelligence system to support problem analysis and solution design for complex social issues. *Technol Forecasting & Social Change* 133: 279-286.

Tutorial: Research skills and detecting BS on the internet.

3) Sept 25: A very short history of communication technologies leading to “what is the Internet”? Prof. Ishtiaque Ahmed, Dept. of Computer Science

To know the future we need to look at the past. We very briefly review communication technologies that bring us to the Internet. What is the Internet? What is it made of and how does it work?

Required Readings:

- Blum, A. 2012. The Map. In: *Tubes: A Journey to the Center of the Internet*. Harper Collins, Toronto. Chapter 1, p. 11-34.
- Read: How Does the Internet Work?
https://developer.mozilla.org/en-US/docs/Learn/Common_questions/How_does_the_Internet_work

Recommended Sources:

- Watch: Videos that demonstrate how internet technology works:
http://www.youtube.com/watch?v=7_LPdttKXPc
<http://www.youtube.com/watch?v=qv0XCauKfNk>
<http://www.flixy.com/how-the-internet-works.htm>

4) Oct 2: Is the Internet green? An energy analysis.

To answer the question “Is the Internet green?” we examine the energy used in ICT. We are interested in energy use because of related releases of greenhouse gases and thus contributions to increasing the rate and severity of climate change. We introduce the environmental analysis tools of mass balance analysis and Life Cycle Assessment.

Required Readings:

- Williams, E. 2011. Environmental effects of information and communications technologies. *Nature* 479: 354-358. DOI: 10:1038/nature10682.

- Teehan, P., Kandikar, M. 2013. Comparing embodied greenhouse gas emissions of modern computing and electronics products. *Environmental Science & Technology* 47: 3997-4003. Focus your reading on the Introduction and Results and Discussion.

Recommended Sources:

- Lee, L-C., Wang, Y., Yan, Y., Zuo, J. 2018. Greenhouse gas emissions embodied in the Chinese international trade of computer products. *Sustainability* 10(5). DOI: 10.3390/su10051623
- Koomey, J.G., Matthews, H.S., Williams, E. 2013. Smart everything: will intelligent systems reduce resource use? *Annual Review of Environment and Resources* 38: 311-343. Read pages 311-315 (read until "Efficiency of low-energy computing), 328-334.
- The Global Footprint Network. <http://www.footprintnetwork.org/en/index.php/GFN/>
- Williams, D.R., Tang, Y. 2013. Impact of office productivity cloud computing on energy consumption and greenhouse gas emissions. *Environmental Science & Technology* 47, 4333-4340.
- Boyd, S.B., Horvath, A., Dornfeld, D. 2009. Life-cycle energy demand and global warming potential of computational logic. *Environmental Science & Technology* 43, 7303-7309.
- <http://www.lowtechmagazine.com/2009/06/embodied-energy-of-digital-technology.html>

Tutorial: Workshop Assignment 1.

5) Oct 9: Beyond the carbon footprint: the Internet's resource use.

The ICT sector is a major user of industrial energy, and high purity, strategic minerals and critical metals. Our rapacious use of these minerals, their "criticality" and difficulties with recycling them may cause shortages which could curb our ability to produce new IT products. Moreover, some of these strategic minerals are conflict commodities or have ethical geo-political implications. How do we combine the exponential growth in ICT gadgetry with resource limitations? Who pays the price for resource extraction and who benefits from these resources?

Required Readings:

- Reller, A., Bublies, T., Staudinger, T., Oswald I., Meißner S., Allen, M. 2009. The mobile phone: powerful communicator and potential metal dissipator. *GAIA* 18/2: 127-135.
- Moran, D., McBain, D., Kanemoto, K., Lenzen, M., Geschke, A. 2014. Global supply chains of coltan: a hybrid Life Cycle Assessment study using a social indicator. *Journal of Industrial Ecology* 19(3): 357-365. DOI/10.1111/jiec.12206/ Please read the paper except for the methods section (unless you are very interested in the methods used!).

Recommended Sources:

- Gulley, A.L., Nassar, N.T., Xun, S. 2018. China, the United States, and competition for resources that enable emerging technologies. *Proc Nat Acad Sci* 115(16): 4111-4115. DOI: 10.1073/pnas.1717152115
- <https://www.facebook.com/mineraljustice>
- <https://www.amnesty.org/en/latest/news/2016/01/Child-labour-behind-smart-phone-and-electric-car-batteries/>

6) Oct 16: Resources in and e-waste out.

One of the unintended consequences of using so many ICT gadgets and frequently upgrading them is the mountain of e-waste that must be dealt with. How big is the mountain of e-waste? What are the

environmental, social and economic consequences of the mass of e-waste being produced and how do those consequences vary depending on where you live? This is the first of two lectures on e-waste with the first focusing on the mass of e-waste generated, where and how it is handled and why recycling is challenging.

Required Readings:

- Tansel, B. 2017. From electronic consumer products to e-wastes: Global outlook, waste quantities, recycling challenges. *Environ Int* 98: 35-45. doi.org/10.1016/j.envint.2016.10.002

Recommended Sources:

- Baldé, C. P.; Wang, F.; Kuehr, R.; Huisman, J. *The Global E-Waste Monitor 2014: Quantities, Flows and Resources*; Bonn, Germany, 2015.
- Zhang, K., Schnoor, J.L., Zeng, E.Y. 2012. E-waste recycling: where does it go from here? *Environmental Science & Technology* 46: 10861-10867. DOI: 10.1021/es303166s
- Zeng, X., Congren, Y., Chiang, J.F., Li, J. 2017. Innovating e-waste management: from macroscopic to microscopic scales. *Sci Total Environ* 575: 1-5. doi.org/10.1016/j.scitotenv.2016.09.078

Tutorial: Peer review of assignment 1.

7) Oct 23: Challenges and Solutions of dealing with e-waste

We have this mountain of e-waste. What are the implications of handling e-waste in terms of human and ecological health? solutions to best deal with it? We also look at technologies for recycling, but those technologies can only be implemented if they are “economic”. Thus, we look into the actual feasibility of implementing e-waste recycling solutions in terms of economics and the regulatory system.

Required Readings:

- Bakhiyi, B., Gravel, S., Ceballos, D., Flynn, M.A., Zayed, J. 2018. Has the question of e-waste opened a Pandora’s box? An overview of unpredictable issues and challenges.

Recommended Sources:

- Fitzpatrick, C., Hickey, S., Schischke, K. Maher, P. 2014. Sustainable life cycle engineering of an integrated desktop PC: a small to medium enterprise perspective. *Journal of Cleaner Production* 74: 155-160.
- Awasthi, A.K., Wang, M., Wang, Z., Awasthi, M.K., Li, J. 2018. E-waste management in India: A mini-review. *Waste Management Res* 36(5): 408-414.
- Listen: CBC Spark with Nora Young. Episode 212: Get it, Keep it, Fix it <http://www.cbc.ca/radio/spark/212-get-it-keep-it-fix-it-1.2847823>

8) Oct 30: The Internet and Mental Health.

With a half of the global population using the Internet and with Internet usage continuing to rise, what are the consequences to individual health? Do we have agency in controlling health impacts? What are the consequences to individual mental health? Are the health consequences experienced equitably amongst all users?

Required Readings:

- Twenge, J.M. 2017. Have smartphones destroyed a generation? *The Atlantic* September edition. <https://www.theatlantic.com/magazine/archive/2017/09/has-the-smartphone-destroyed-a-generation/534198/>

Recommended Sources:

- Twenge, J.M., Joiner T.E., Rogers M.L., Martin, G.N. 2018. Increases in depressive symptoms, suicide-related outcomes, and suicide rates among U.S. Adolescents after 2010 and links to increased new media screen time. *Clinical Psychol Sci* 6(1): 3-17.
- Coyne, S.M., Padilla-Walker, L.M., Howard, E. 2013. Emerging in a digital world: a decade review of media use, effects, and gratifications in emerging adulthood. *Emerging Adulthood* 1(20): 125-137.
What the Internet is doing to our brains. YouTube Video from Nicolas Carr
<https://www.youtube.com/watch?v=cKaWJ72x1rl>

Tutorial: Workshop Assignment 2.

9) Nov 6: The Environmental Benefits of the internet, Milan Ilnyckyj

We have discussed the energy and resource implications of the internet. However, the internet offers many opportunities and benefits for environmental sustainability. What are some of those benefits? How can the internet contribute to achieving the United Nations Sustainable Development Goals?

Required Readings:

- Internet Society. 2015. The Internet and Sustainable Development. <http://www.internetsociety.org/doc/internet-and-sustainable-development>

Recommended Sources:

- United Nations Millennium Development Goals <http://www.un.org/millenniumgoals/>

Nov 13: Reading Break**10) Nov 20: Why do we embrace the Internet and other new technologies? The idea of progress.**

The notion of progress has been a dominant idea in western thinking since the enlightenment. The idea that life for each generation should get steadily better shapes our expectations from technology, and pushes us to value innovation and economic growth. This class will explore ideas about progress and innovation from a number of perspectives, including those of other cultures who do not share a myth of progress, from the historical perspective (including the myths around inventors as “great men of history”), from an environmental perspective where concerns about sustainability on a finite planet come into direct conflict with the growth imperative, and from an economics perspective, where the opportunity cost of investment in internet innovation must be weighed against other ways of investing our time and effort, such as such as clean energy, transport, food production, and social innovation.

Required Readings:

- Franklin, U. 2004. *The Real World of Technology*. Revised Edition, House of Anansi; Toronto. Revised edition. Chapter 1, p. 1-26.

- Huesemann, M. and Huesemann J. 2011. Technological Optimism and Belief in Progress. In Huesemann, M. and Huesemann J. *Techno-Fix. Why Technology Won't Save Us or the Environment*. New Society Publishers; Gabriola Island, Canada. Chapter 7, p.145-159, 167-172.

Recommended Sources:

- Taylor, C. 1991. *The Malaise of Modernity*. House of Anansi; Toronto.
- Vergragt, P.J. "How Technology Could Contribute to a Sustainable World" Great Transition Institute Working Paper, 2006:
<http://www.gtinitiative.org/documents/PDFFINALS/8Technology.pdf>

Tutorial: Peer review of Assignment 2.

11) Nov 27: Are we in the midst of a technological revolution?

Some commentators say that IT is the third technological revolution and that we are now in the midst of it. Evidence for the revolution comes from rapid innovation and change in numerous sectors. As with past technological revolutions, no one knows what the future holds but that there are and will be "winners and losers". This is particularly salient for youth employment. We will explore these themes and tie them in with those introduced over the term.

Required Readings:

Naughton, J. 2012. Chapter 1. Take the long view. In: *What you really need to know about the Internet*. Quercus; London. p. 9-38.

Recommended Sources:

- Franklin, U. 2004. *The Real World of Technology*. Revised Edition, House of Anansi; Toronto. Revised edition. Chapters 7 & 9, p. 134-156.
- Homer-Dixon, T. 2000. *The Ingenuity Gap*. Toronto: Vintage Canada (Random House); Toronto.
- Episode on Spark "[Race against the machine](http://www.cbc.ca/player/Radio/Spark/ID/2247357704/)"
<http://www.cbc.ca/player/Radio/Spark/ID/2247357704/>

12) Dec 4: Integration and review.

Good grief. The lectures have finished! What did we learn? What are some of the major questions that have been raised but not answered? What should I know for the exam?