UNITED STATES DISTRICT COURT
SOUTHERN DISTRICT OF NEW YORK

CONSUMER ELECTRONICS ASSOCIATION, INFORMATION TECHNOLOGY INDUSTRY COUNCIL, and ITAC SYSTEMS, INC.

Plaintiffs,

v.

CITY OF NEW YORK, MICHAEL R. BLOOMBERG, in his official capacity as Mayor of the City of New York, NEW YORK CITY DEPARTMENT OF SANITATION, JOHN J. DOHERTY, in his official capacity as the Commissioner of the Department of Sanitation, and ROBERT LANGE, in his official capacity as Director of Waste Prevention, Reuse and Recycling of the Department of Sanitation,

Defendants.

09 Civ. 6583

DECLARATION OF PROFESSOR ERIC WILLIAMS, PH.D. IN SUPPORT OF PLAINTIFFS' MOTION FOR A PRELIMINARY INJUNCTION

Declaration of Professor Eric Williams, Ph.D.

I, Eric Williams, declare as follows:

1. The following facts and opinions are true to my own personal knowledge and if called as a witness I could so testify.

2. My summary opinion is that New York City's electronic equipment collection, recycling, and reuse program is inconvenient, inefficient, and substantially inferior to other collection and recycling programs for discarded electronic waste ("e-waste") that have been successfully implemented across the United States and abroad.

3. I am an Assistant Professor at Arizona State University with a joint appointment between the School of Sustainable Engineering and the Built Environment and the School of Sustainability. I am the Research Director for the Center for Earth Systems Engineering and Management, a center devoted to improved understanding and management of the environmental,

economic and social implications of technology. I have been a faculty member at Arizona State University since 2006, before which I was a Visiting Assistant Professor at Carnegie Mellon University in Pittsburgh. I have a Ph.D. in theoretical physics which I received from the State University of New York at Stony Brook in 1993.

4. My main research area for the past seven years has been the environmental management of producing, using and recycling of electronic devices. I am considered an authority in this area. I have done what many consider landmark works on the environmental management of computers such as my article, "The 1.7 kilogram Microchip," published in 2002 in the journal, *Environmental Science & Technology*, and my book, *Computers and the Environment: Understanding and Managing their Impacts*, published in 2004. Last year, I testified before the U.S. Congress, *Electronic Waste: Can the Nation Manage Modern Refuse in the Digital Age?: Hearing Before the H. Comm. on Science and Technology*, 110th Cong. (2008). This hearing resulted in the development of the Electronic Waste Research and Development Act, H.R. 1580, 111th Cong. (April 2009), legislation designed to fund research to address the fundamental question of how to manage discarded electronics. The bill recently passed the House of Representatives and is currently before the Senate.

5. I served as a member of the Committee on Point of Use and Full Fuel Cycle Measurement Approaches to Energy Efficiency Standards of the National Academy of Sciences, which produced a report on appliance energy efficiency standards. I am also a member of the Board of Councilors for the Green Electronics Council, a non-governmental organization that develops and administers Electronic Product Environmental Assessment Tool (EPEAT), the primary environmental certification for computers in the United States. See www.epeat.net.

6. I have published 14 peer-reviewed journal articles and book chapters on the

environmental management of electronics. Results of my research have been widely covered in the scientific and popular media, with articles in *Science*, *Nature*, *Scientific American*, *Business Week*, *Financial Times*, *Foreign Policy*, *National Public Radio* and other outlets. I have presented work at international and trade conferences. My expertise in the area of electronics recycling and waste issues extends to the international arena. I regularly travel to Asia, and work with prominent organizations on global e-waste issues, including Japan's Institute for Global Environmental Strategies. My curriculum vitae is attached to this declaration.

7. I have been asked to provide an expert opinion regarding the potential effectiveness, costs and environmental performance of the laws, regulations and accompanying forms underlying New York City's new system mandating the collection and recycling of e-waste (collectively referred to as the "NYC e-waste program"). I understand that this Declaration will be used in support of a motion for a preliminary injunction. I am receiving compensation for my work in the amount of $250 per hour.

8. In addition to my research, experience, and knowledge of policies related to the collection and recycling of e-waste, in preparation for this Declaration I have reviewed the following information:

a) Local Laws Nos. 13 and 21 ("NYC e-waste law")
b) New York City Department of Sanitation ("DSNY") Notice of Adoption of Final Rules Governing Electronic Equipment Collection, Recycling, and Reuse ("NYC e-waste rules")
c) Electronic Waste Management Plan Submission Forms – Instructions, and Sections P-1 through P-5
d) City of New York, City Environmental Quality Review ("CEQR") Negative Declaration, Statement of No Significant Effect (March 11, 2008)
e) CEQR Type II Determination Concerning Proposed Rules Implementing Local Law No. 13 of 2008 with respect to E-waste Collection (May 7, 2009)

9. My opinion regarding the NYC e-waste program is summarized below:

a) The logistics mandated by the NYC e-waste rules' requirement of door-to-door collection of e-waste greater than 15 pounds are highly inefficient and likely to induce unnecessary and considerable adverse transportation and environmental impacts including increased traffic congestion, noise and air quality impacts.

b) The e-waste collection requirement is *inconvenient* for City residents, in direct conflict with Local Law No. 13's stated goal of creating a convenient system.

c) To its detriment, the NYC e-waste program differs from other programs in the United States and nations around the world mandating e-waste collection and recycling – particularly in requiring door-to-door collection by manufacturers. The program is resource intensive, expensive and likely to be less successful due to poor participation by residents.

d) The environmental cost-benefit analyses carried out by the City Council and DSNY to justify the e-waste program were superficial, and the results contradict the stated tenets of the program.

I elaborate on each of these points below.

10. The typical e-waste collection and reuse/recycling system is a multi-stage process that involves transporting devices from the consumer's home or business, to the appropriate recycling facility. In the typical scenario, the consumer brings a used device to an electronics retail store. The retailer transports the device from the store, often using a small truck, to a collection point where e-waste is gathered into batches. Large trucks then convey the batches of e-waste to a reuse/recycling facility where the device is checked for resale value and resold if appropriate. If reuse is not an option, the device then enters the recycling process. Specifically, it is disassembled by hand and/or shredded by machine to separate different materials and parts such as steel, copper, aluminum, glass, plastic, and circuit boards. Certain components such as batteries and circuit boards are shipped to separate facilities and undergo specialized recycling processes.

11. As previously referenced, the first and most critical step of collection is collection

and transport of devices from the consumer's residence to some centralized point. Transport typically follows one or a combination of six methods:

a) Curbside pick-up: The resident puts a device outside the home for pick-up by the relevant waste management service.[1] Note that currently, in NYC, residents can place up to six bulk items, including appliances, televisions, and computer monitors, on the curb for DSNY to pick-up free-of-charge.[2] Under the NYC e-waste program, residents will be banned from curbside disposal as of July 1, 2010.

b) Retailer swap-out: The retailer collects old devices when delivering new ones, regardless of the manufacturer of the old device.[3] This system piggybacks on the appointment already made for delivery. The resident does not need to read information, initiate communication or make appointments to be at home for a separate pick-up of the old device. The swap-out system is used for larger devices in a variety of urban areas such as Tokyo, Washington D.C., and Vancouver.

c) Mail/courier pick-up: The consumer packages the device for transport and it is picked up at the residence by postal or courier service. This is a common approach, nationwide, for returning cell phones for recycling.

d) Dedicated pick-up at residence: The collecting organization dispatches a truck directly to the consumer's home for the purpose of picking up the device to be discarded. The NYC e-waste program utilizes this method, and to my knowledge is the only program in the world which requires manufacturers to pick-up at residences.

e) Drop-off point: The consumer brings the device to a designated drop-off point, such as an electronics retailer or a municipal recycling center.

f) Collection event: In this approach, periodic events are held by municipalities or other organizations, where consumers bring devices in to be recycled.

12. The various collection methods differ in terms of convenience for consumers and efficiency of logistics. A "convenient collection" system, as required by the NYC e-waste rules, requires minimizing the resident's time and effort. Also, different factors like the size of the device being recycled and the type of residential area (*i.e.* urban, suburban, or rural area) affect

[1] H. Kang and J. Schoenung, *Electronic waste recycling: A Review of U.S. Infrastructure and Technology Options,* 45 Resources, Conservation and Recycling 368–400 (2005).
[2] *See* DSNY, Bulk Collection, *available at* http://www.nyc.gov/html/dsny/html/collection/bulk.shtml.
[3] M. Savage, *Implementation of the Waste Electric and Electronic Equipment Directive in the EU*, European Commission Joint Research Service, Catalogue Nr.: LF-NA-22231-EN-C (2006).

the convenience and efficiency of e-waste collection.

13. For devices over 15 pounds, the NYC e-waste rules prescribe a collection system which is both inefficient and inconvenient for two reasons. First, the program engages only the manufacturer and the resident in the collection process, leaving other critical stakeholders such as the City and retailers out of the process. Maine's successful program, for example, mandates participation in addition to manufacturers from state and local government, private consolidators, recyclers, and retailers.[4] Second, the mandated direct collection options are inconvenient and inefficient compared to other options, elaborated further below.

14. The direct collection requirement mandated by the NYC e-waste rules, stipulates that for devices over 15 pounds, manufacturers must engage in:

> "direct collection from a resident's home in the City, which may include a postal or parcel service but need not include collection from inside such home ('direct collection program'). A direct collection program may not include collection of electronic equipment left for collection at the curbside."

There are two ways to implement this stipulation: (1) mail/courier pick-up; or (2) dedicated pick-up at the residence.

15. The inconvenience of the mail/courier pick-up option is best illustrated through a review of the steps a City resident would have to take to use such an option:

a) First, the resident must obtain a written explanation of the NYC e-waste program, either in printed or internet form. There will be different recycling systems for different types of devices.

b) After determining that the device is to be returned through mail/courier service, the resident must identify and contact the appropriate manufacturer. If a resident's device was made by a registered manufacturer, the device can be matched with a list for purposes of

[4] The Electronic Takeback Coalition ("ETBC"), a national coalition of environmental and consumer groups promoting responsible recycling and green design in the electronics industry, cited Maine's e-waste program as a state with "strong laws" that have resulted in high take back volumes. Maine has collected over 10 millions pounds of e-waste, averaging 3.5 pounds per capita annually. *See* ETBC, *Which State Collects the Most E-Waste?* (May 22, 2009), *available at* http://www.electronicstakeback.com/legislation/Collection_Volumes_by_State.pdf.

initiating contact. If the device was not made by a registered manufacturer (*i.e.*, orphan waste, in which the manufacturer is no longer active in the market) the resident must establish that the new purchased device is of the same type made by a registered manufacturer. Even after 2011, when manufacturers will be required to take orphan waste without a purchase, the resident will still need to find a registered manufacturer that sells the same type of product as the orphan waste item in order to recycle the item in accordance with the NYC e-waste program.

c) The resident must then contact the appropriate manufacturer, and in most cases, order packaging. In some cases the consumer may still own the original box, but in NYC, where storage space is limited, this will be the exception, not the rule. The resident may also need to be home to receive the shipment of packaging material.

d) Finally, the resident must package the device and contact the mail/courier service to arrange pick-up. Often the consumer will need to be at home to hand off the package. If the resident is disposing of more than one device purchased from different manufacturers, the above-referenced process must be repeated for each device.

The above-described process-flow is manifestly inconvenient. It is also inefficient because of the need for two trips by the mail/courier service, one to deliver packaging and one to pick-up the device.

16. The dedicated pick-up at residence option is even more inconvenient and inefficient. The process flow essentially follows that of the mail/courier service option above with two differences: (1) advance packaging is not required; and (2) the resident will likely need to be at home to allow the pick-up service to enter her home to package and collect the device. This system is also inefficient due to the need to dispatch a truck specifically to make the pick-up, clearly increasing the number of trucks on NYC streets.

17. The NYC e-waste system is needlessly inconvenient and inefficient when compared to better designed collection systems around the world. Other nations and U.S. states recognize the superior performance of approaches such as curbside pick-up and retailer swap-out for collecting large electronics. There are 19 U.S. states, including California, Maine, Oregon

and Washington State,[5] and other foreign countries such as Japan, Taiwan, Korea, Switzerland, and European Union member states that have experience implementing e-waste collection systems. Each program is different in terms of organizational structure, financing mechanisms and collection systems, but to my knowledge, no program, other than NYC, requires manufacturers to carry the entire burden of direct collection of "large" electronic devices from individual residences. Indeed, the only example I am familiar with of using mail/courier service to collect a large electronic device is Japan's computer recycling law, which requires the consumer to package and return via mail computers for recycling. This computer collection program is plagued by low participation. Televisions in Japan are collected through retailer swap-out. Other jurisdictions which favor the retailer swap-out or curbside approach for collecting large devices in dense urban areas, include much of California, Washington D.C., Tokyo and Vancouver.

18. The inconvenience and inefficiency of the NYC e-waste collection system will have serious ramifications: (1) there will be a risk of poor participation by residents; and (2) potentially serious and needless environmental impacts may result.

19. Inconvenient and cumbersome collection systems are unsuccessful because residents do not widely use them and little waste is collected.[6] In the case of the NYC e-waste program, this concern is particularly present given the multiple steps residents have to take to arrange collection of e-waste in contrast with the more convenient approaches such as curbside collection or a retailer swap-out system that have been implemented by e-waste programs in the

[5] Electronic Take Back Coalition, "States Are Passing E-Waste Legislation," *available at* http://www.electronicstakeback.com/legislation/state_legislation.htm.

[6] U.S. Envtl. Prot. Agency, *Analysis of Five Community Consumer/Residential Collections End-of-Life Electronic and Electrical Equipment*, EPA-901-R-98-003 (1999); Solve the E-waste Problem Initiative (StEP), *2008 Review of Directive 2002/96 on Waste Electrical and Electronic Equipment (WEEE)*, United Nations University (2008); J. Wang, L. Han and S Li, *The Collection System for Residential Recyclables in Communities in Haidian District, Beijing: A Possible Approach for China Recycling*, 28 Waste Management 1672–1680 (2008).

U.S. and around the world.

20. There are also potentially significant environmental impacts including congestion and increased air emissions. Both mail/courier and direct pick-up collection methods will increase truck traffic on NYC streets, the former through additional courier trips to deliver packaging, and the latter through dedicated trips to pick-up equipment at consumers' homes. Additional trucks on the streets of NYC will inevitably lead to adverse impacts including increased vehicle emissions, congestion, noise pollution, and the associated environmental and health consequences of such impacts. These are particularly significant for trucks due to both size, and the fact that trucks often have to be left double parked with the engine idling during pick-up.[7] In fact, the NYC e-waste program potentially compounds an already serious problem in NYC where congestion impacts productivity and the environment. Between 1995 and 2005, the annual delay per traveler in the New York-Newark area increased from 30 to 46 hours, equating to $888 per peak traveler, per year in congestion costs, and 29 gallons of wasted fuel per peak traveler, per year.[8] Air quality in NYC could suffer from the NYC e-waste program since vehicle emissions dominate most criteria air pollutants.[9] Significantly, these adverse environmental impacts contradict the stated tenets of the program -- to "reduce the environmental and health costs associated with electronic waste," "enhance and maintain the quality of the environment," and "help prevent air, water, and land pollution." Local Law No. 13, § 1.

21. The City's analyses of the environmental and economic impact of the legislation and Rules are superficial. For the mandated NYC e-waste program, two CEQR determinations

[7] *See* U.S. Envtl. Prot. Agency, *Health Assessment Document For Diesel Engine Exhaust*, EPA/600/8-90/057F (2002) and U.S. Envtl. Prot. Agency, *Study of Exhaust Emissions from Idling Heavy-Duty Diesel Trucks and Commercially Available Idle Reducing Devices*, EPA 420-R-02-025 (2002).
[8] Texas Transportation Institute, 2007 Annual Urban Mobility Report, Texas A&M University.
[9] U.S. Envtl. Prot. Agency, *AirData: Access to Air Pollution Data*, *available at* http://www.epa.gov/oar/data/.

of environmental assessment were prepared – one by the City Council for the proposed NYC e-waste law on March 11, 2008 (CEQR Negative Declaration, Statement of No Significant Effect) and another by DSNY for the adopted NYC e-waste rules on May 7, 2009 (CEQR Type II Determination). For the NYC e-waste law, the City Council determined that it did not have a significant adverse impact on the environment. Specifically, it concluded:

> "The action would not . . . lead to a significant increase in truck traffic on the city's roadways. A few additional carting trucks may be deployed to pick-up the covered electronic equipment for recycling. The CEQR Technical Manual guidelines suggest that project generating fewer than fifty peak-hour vehicle trips should not raise traffic concerns and there, should not require detailed traffic analysis. The proposed action would generate far fewer vehicle trips for trucks than that threshold value. . . . Much of the covered equipment would be returned by existing return methods such as mail, parcel, service companies and delivery trucks that are already making return trips."

The City Council's CEQR statement, however, failed to articulate what analysis it conducted to reach such a conclusion. The City Council apparently did not analyze different collection options beyond mail/courier service and delivery trucks[10] or the additional environmental and traffic impacts from transporting the collected e-waste to recycling/reuse facilities before making what is, to all available evidence, a cursory determination that the e-waste law would generate fewer than fifty peak-hour vehicle trips and have no significant effect on traffic or the environment. Given that the law as analyzed by the City Council *did not* mandate direct collection for e-waste greater than 15 pounds, it is difficult to imagine that the City Council's CEQR analysis addressed the environmental, economic, and transportation impacts that would result from the direct collection requirements that DSNY later included in the rules. It is similarly difficult to imagine that no follow-up analysis was required after DSNY finalized the direct collection rules.

[10] The City Council's CEQR analysis was done in March 2008, *before* DSNY mandated direct collection of e-waste greater than 15 pounds in its e-waste rules.

22. In the subsequent CEQR Type II determination dated May 7, 2009 – created by DSNY after it finalized the NYC e-waste rules – DSNY determined that the rules required no further environmental review despite the fact that the rules created a direct collection requirement for e-waste greater than 15 pounds and neither the direct collection mandate nor the 15-pound threshold were included in the e-waste law. With the creation of these new requirements in the e-waste rules that were not in the e-waste law, DSNY needed to conduct a robust and thorough environmental and traffic analysis that first estimated the quantity of e-waste in NYC that is greater than 15 pounds, second, identified the various types of residential areas including density and property types at issue in each borough, and then assess the environmental and traffic implications of direct collection options like dedicated pick-up and mail/courier service in light of those estimates. However, the CEQR document prepared by DSNY contained no substantive information or analysis beyond referencing the previous CEQR Negative Declaration that did not address any of these aforementioned factors and was issued by the City Council for a law that did not mandate direct collection of e-waste greater than 15 pounds. For the City Council's CEQR analysis to be relevant and applicable to the DSNY's new direct collection requirements, the City Council would have needed to analyze direct collection requirement and the 15-pound threshold as a possible collection option for NYC residents. However, as discussed above, the City Council apparently did not make such an analysis.

23. Currently, residents can recycle e-waste items at non-profit reuse donation events and through voluntary manufacturer and retailer "take back" programs.[11] For any remaining e-waste discarded as solid waste, without a more robust environmental review, it is unclear what environmental benefits the NYC e-waste program will derive for NYC – particularly in

[11] DSNY, Electronics Recycling, *available at* http://www.nyc.gov/html/nycwasteless/html/recycling/electronicsrecycling.shtml#dsny-events.

comparison to the current NYC practice of incinerating such e-waste at federal and state permitted waste-to-energy facilities[12] or disposing the e-waste in licensed landfills. Although recycling and reuse of e-waste has environmental benefits, available scientific evidence suggests that the risk of toxics leaching from e-waste in licensed landfills is not significant.[13] As articulated by Barry Breen, former Deputy Assistant Administrator for EPA's Solid Waste and Emergency Response before a Congressional Hearing in 2005, the chemical conditions (such as pH) in actual landfills do not encourage leaching of heavy metals (such as lead) from e-waste. Mr. Breen reasoned that even if leaching occurred, modern landfills have leachate collection systems that prevent potential e-waste contaminants from reaching the environment. Even if the leachate collection system failed, he concluded that the dilution factor in groundwater would lead to contamination levels well below regulatory limits.[14]

24. In addition, Local Law 13 states that "the regional incineration of electronic waste poses a direct threat to the city's air quality and the health of its residents." Even after the NYC e-waste program is implemented by the manufacturers, many other types of e-waste such as cell phones, stereos, VCRs, and DVD players, will continue to be collected by DSNY and sent to landfills and waste-to-energy facilities because these small electronic items have been excluded from the scope of the NYC e-waste program and may still be disposed as solid waste after July 2010. Given that, it is not clear what amount of e-waste would be diverted from regional waste-

[12] A waste-to-energy facility is a "specially designed waste management facilities where waste is burned to create energy, which is captured for use in generating electricity." U.S. EPA., *Waste Education Materials: Glossary of Terms*, *available at* http://www.epa.gov/osw//education/quest/gloss1a.htm.

[13] *See* E. Williams, R. Kahhat, B. Allenby, E. Kavazanjian, J. Kim and M. Xu. *Environmental, Social and Economic Implications of Global Reuse and Recycling of Personal Computers*, 42 Environmental Science & Technology. 6446-6454 (2008); Y. Jang and T. Townsend, *Leaching of Lead from Computer Printed Wire Boards and Cathode Ray Tubes by Municipal Solid Waste Landfill Leachates*, 37 Environmental Science &. Technology. 4778-4784 (2003); and *The Effectiveness of Municipal Solid Waste Landfills in Controlling Releases of Heavy Metals to the Environment*, Solid Waste Association of North America Applied Research Foundation, Silver Springs, MD. (Nov. 2004) (revised).

[14] *Electronic Waste: An Examination of Current Activity, Implications for Environmental Stewardship and the Proper Federal Role Before the Subcomm. on Env. and Hazardous Materials of the H. Comm. on Energy and Commerce*, 109th Cong. 23-33 (2005).

to-energy facilities as a result of the e-waste program and whether the potential benefit of air emissions reduction from less incineration of e-waste would eclipse the increased vehicle air emissions from the additional diesel trucks required to directly collect residential e-waste over 15 pounds.

25. Given the significant investments in money and time by both manufacturers and residents, responsible policy making obliges the City Council and DSNY to clarify their environmental objectives and undertake a meaningful and substantive environmental and cost-benefit analysis to clarify the implications of its mandate. The need for such analysis is even greater given the fact that the DSNY has chosen to pioneer an unproven and facially burdensome approach to e-waste collection. The City Council and DSNY should undertake a much more significant effort to analyze, document and justify the NYC e-waste program -- a program that will result in potentially significant environmental and economic impacts.

26. In summary, my opinion is that NYC's e-waste program is inconvenient, inefficient, and substantially inferior to other collection and recycling programs for discarded electronic waste that have been successfully implemented across the United States and abroad. Moreover, the environmental cost benefit analyses performed by the City Council and DSNY to justify the program were apparently superficial.

27. I declare under penalty of perjury that the foregoing is true and correct.

Executed this 6th day of August 2009 in Tempe, Arizona.

Eric Williams, Ph.D.

CURRICULUM VITAE

Eric David Williams

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Education

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1988 B.A. in Physics,
Macalester College, St. Paul, Minnesota

Professional Experience

8.2008 - present	Research Director, Center for Earth Systems Engineering and Management, Arizona State University
8.2006 - present	Assistant Professor, Department of Civil, Environmental and Sustainable Engineering & School of Sustainability, Arizona State University, Tempe
9.2005 - 7.2006	Visiting Assistant Professor, Department of Civil and Environmental Engineering, Carnegie Mellon, Pittsburgh
9.2001 - 7.2006	Project Coordinator, United Nations University/Centre, Tokyo
9.2000 - 8.2001	Associate Fellow, United Nations University/Institute of Advanced Studies, Tokyo, Japan
9.1997 - 8.2000	Research Associate, United Nations University/Institute of Advanced Studies, Tokyo, Japan
9.1995 - 8.1997	JSPS Postdoctoral Fellow, Institute for Solid State Physics, University of Tokyo, Japan
9.1994 - 8.1995	Temporary Assistant Professor, Department of Mathematics, University of Minnesota, Minneapolis
9.1993 - 8.1994	Visiting Researcher, Department of Mathematics, University of Minnesota, Minneapolis

a) Publications

Articles in refereed journals

1. E. Williams, C. Weber and T. Hawkins, "Survey and Hybrid Approach to Managing Uncertainty in Life Cycle Inventories", in press, *Journal of Industrial Ecology* (2009)
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14. H.S. Matthews and E. Williams, "Telework adoption and energy use in building and transport sectors in the US and Japan", *Journal of Infrastructure Systems* 11(1), 21-30 (2005)
15. E. Williams, "Energy intensity of computer manufacturing: hybrid analysis combining process and economic input-output methods", *Environmental Science & Technology* 38(22), 6166 - 6174 (2004)
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24. E. Williams, "Exact wavefunctions for a delta function Bose gas with higher derivatives", *Physics Letters* A 223, 19-22 (1996)
25. E. Williams, "Thermodynamics and excitations of the supersymmetric t-J model", *International Journal of Modern Physics*, B9 (27), 3607-3624 (1995)
26. E. Williams, "Strings complete the spectrum of 1-D δ-function fermions", *Modern Physics Letters* B7, 689-701 (1993)

Books, monographs, conference proceedings

1. R. Kuehr and E. Williams (eds.), *Computers and the Environment: Understanding and Managing their Impacts*, Kluwer Academic Publications: Dordrecht (2003)
2. E. Williams, *Global Production Chains and Sustainability: the case of high-purity silicon and its applications in Information Technology and renewable energy*, United Nations University/Institute of Advanced Studies: Tokyo, 140 pages (2000)
3. C. Suzuki and E. Williams (eds.), *Proceedings of the First Workshop on the Quartz Industrial Trade System*, United Nations University/Institute of Advanced Studies: Tokyo, ISBN# 4-906686-C, 248 pages (1998)

Book chapters

1. R. Kuehr, J, Velasquez and E. Williams, "Computers and the environment—an introduction to understanding and managing their impacts", in R. Kuehr and E. Williams (eds.),

Computers and the Environment: Understanding and Managing their Impacts, Kluwer Academic Publications: Dordrecht, 1-16 (2003)
2. E. Williams, "Environmental impacts associated with the production of personal computers", in R. Kuehr and E. Williams (eds.), *Computers and the Environment: Understanding and Managing their Impacts*, Kluwer: Dordrecht, 41-72 (2003)
3. E. Williams and Y. Sasaki, "Strategizing the end-of-life handling of personal computers", in R. Kuehr and E. Williams (eds.), *Computers and the Environment: Understanding and Managing their Impacts*, Kluwer: Dordrecht, 183-196 (2003)
4. E. Williams and R. Kuehr, "Today's Markets for Used PCs—And Ways to Enhance Them", in R. Kuehr and E. Williams (eds.), *Computers and the Environment: Understanding and Managing their Impacts*, Kluwer: Dordrecht, 197-210 (2003)
5. E. Williams, "Environmental Life Cycle Assessment and Municipal Solid Waste Management", in *Encyclopedia of Life Support Systems*, E1-18: Institutional and Infrastructural Resources, Human Settlement Development, edited by Saskia Sassen, United Nations Educational, Scientific and Cultural Organization: Paris (2003)

Articles in conference proceedings and reports

1. E. Williams, "Framework for Thermodynamic Constraints on Sustainability", to appear in Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and Technology, Phoenix (2009)
2. C. Mattick, E. Williams, and B. Allenby, "Energy and Civilization" to appear in Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and Technology, Phoenix (2009)
3. M. Xu, E. Williams and B. Allenby, "Environmental Overhead of Labor (EOL) Embodied in Trade: The Case of 2002 China-U.S. Trade", to appear in Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and Technology, Phoenix (2009)
4. J. Yu, E. Williams, and M. Ju, "Review and Prospects of Recycling Methods for Waste Printed Circuit Boards" to appear in Proceedings of the 2009 IEEE International Symposium on Sustainable Systems and Technology, Phoenix (2009)
5. C. Harto, R.J. Meyers, and E. Williams, "Life Cycle Water Consumption of Alternative, Low-Carbon Transportation Energy Sources", report to the Arizona Water Institute, December (2008)
6. L. Deng and E. Williams, "Measures and Trends in Energy Use of Semiconductor Manufacturing", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)
7. Y. Yang and E. Williams, "Forecasting sales and generation of end-of-life computers in the U.S.", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)
8. N. Krishnan, E. Williams and S. Boyd, "Case Studies in Energy Use to Realize Ultra-High Purities in Semiconductor Manufacturing", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)
9. R. Kahhat, J. Kim, M. Xu, B. Allenby, and E. Williams, "Exploring e-waste management systems in the U.S.", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)

10. J. Kim, M. Xu, R. Kahhat, B. Allenby, and E. Williams , "Design and Assessment of a Sustainable Networked System in the U.S.: Case study of Book Delivery System", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)
11. E. Williams, R. Kahhat, B. Allenby, E. Kavazanjian, J. Kim and M. Xu, "Sustainability review of the international reverse chain for reuse and recycling of computers", in Proceedings of the 2008 IEEE International Symposium on Electronics and the Environment, San Francisco, CA (2008)
12. E. Williams, B. Warr, and R. Ayres, "Long Term Exergy-efficiency Trends in Japan", in Proceedings of Eco-Design 2007 - 5th International Symposium on Environmentally Conscious Design and Inverse Manufacturing, Tokyo: Japan (2007)
13. E. Williams and H. Scott Matthews, "Scoping the potential of monitoring and control technologies to reduce energy use in homes", in *2007 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 239-244 (2007)
14. C. Weber, H. Scott Matthews, J. Corbett and E. Williams, "Carbon Emissions Embodied in Importation, Transport and Retail of Electronics in the U.S.: A Growing Global Issue", in *2007 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 174-179 (2007)
15. E. Williams, "The case for improved uncertainty analysis of LCI", in *Proceedings of the Seventh International Conference on Ecobalance*, published by the Society for Non-traditional Technology: Tokyo, 249-252 (2006)
16. Hendrickson, C., H.S. Matthews and E. Williams, "Experience with the Economic Input-Output Life-Cycle Assessment Website", in *Proceedings of the Seventh International Conference on Ecobalance*, published by the Society for Non-traditional Technology: Tokyo, 243-244 (2006)
17. E. Williams, H. Scott Matthews, M. Breton and T. Brady, "Use of a computer-based system to measure and manage energy use in the home", *2006 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 161-166 (2006)
18. E. Williams, Mandated prices as an instrument to mitigate environmental impacts in informal reuse/recycling, Proceedings of The Second National Institute for Environment Studies (NIES) Workshop on E-waste: November 23rd, Tokyo, Japan, pp 43-56 (2005).
19. E. Williams and T. Hatanaka, "The relevance of computer usage patterns and secondary markets for energy management", in *Proceedings of the 2005 ACEEE Summer Study on Energy Efficiency in Industry*, American Council for an Energy-Efficient Economy: Washington D.C. (2005)
20. E. Williams, "International activities on E-waste and guidelines for future work", in Proceedings of The Third Workshop on Material Cycles and Waste Management in Asia, National Institute of Environmental Sciences: Tsukuba, Japan, 49-60 (2005)
21. E. Williams and T. Hatanaka, "Residential computer usage patterns in Japan and associated life cycle energy use", in *2005 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 177-182 (2005)
22. E. Williams, "Revisiting Energy used to Manufacture a Desktop Computer", in *2004 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 80-85 (2004)

23. E. Williams, "Hybrid analysis of energy used to manufacture a desktop computer", in *Proceedings of the Sixth International Conference on Ecobalance*, published by the Society for Non-traditional Technology: Tokyo, 71-74 (2003)
24. E. Williams and H.S. Matthews, "Potential impact of telework programs on energy use in the US and Japan", Proceedings of Proceedings of 11th LCA Case Studies Symposium - Environmental Assessment in the Information Society, SETAC: Belgium, 77-80 (2003)
25. E. Williams, "Life cycle energy of computer manufacturing", Proceedings of Proceedings of 11th LCA Case Studies Symposium - Environmental Assessment in the Information Society, SETAC: Belgium, 122-125 (2003)
26. E. Williams, "Assessing the potential of telecommuting as an energy savings technology in Japan", in *2003 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 147-152 (2003)
27. E. Williams, "Energy analysis of end-of-life for personal computers: resell, upgrade, recycle", in *2003 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 187-192 (2003)
28. E. Williams, "Extending PC lifespan through secondary markets", in *2003 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 255-259 (2003)
29. E. Williams and T. Hatanaka, "Sustainable consumption and the Information Technology revolution", in *Proceedings of the First International Workshop on Sustainable Consumption*, Society for Non-Traditional Technology: Tokyo, 69-75 (2003)
30. E. Williams, "Energy efficiency of b2c E-commerce in Japan", in *2002 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 38-43 (2002)
31. E. Williams, R. Ayres, and M. Heller, "Energy and chemical use in the production chain for microchips", in *2002 IEEE International Symposium on Electronics and the Environment*, IEEE: Piscataway, New Jersey, 184-189 (2002)
32. E. Williams and T. Tagami, "Energy analysis of e-commerce and conventional retail distribution of books in Japan", in *Sustainability in the Information Society*, Metropolis Verlag: Marburg, Germany, 73-80 (2001)
33. E. Williams, "Systems Analysis of the Global Production Chain for High-purity Silicon", in *Proceedings of the Fourth International Conference on Ecobalance*, published by the Society for Non-traditional Technology: Tokyo, 577-580 (2000)
34. E. Williams and M. Troyer, "A Framework for Computer Aided Modeling, Design, and Optimization of Integrated Industrial Systems", UNU/IAS Working Paper #54, United Nations University/Institute of Advanced Studies: Tokyo, 20 pages (1998)
35. E. Williams, "Towards Quantitative Design of Zero Emissions Industrial Clusters: Choice of Variables and Fractal Invariance", in *Proceedings of the Targeting Zero Emissions for the Utilization of Renewable Resources*, University of Tokyo: Tokyo, 98-102 (1998).
36. E. Williams, "Computer Models as Description and Design Tools for QITS", in *Proceedings of the First Workshop on QITS*, United Nations University: Tokyo, ISBN# 4-906686-C, 138-144 (1998)
37. J. Gravitis, T. Della Senta, and E. Williams, "The Conversion of Biomass into Fuels, Fibers, and Value-added Chemical Products from the Perspective of the Zero Emissions Concept", in *Proceedings of the Symposium on Biomass Conversion*, Sapporo, Japan, 1-18 (1997)

Fundraising experience/awards

(co-PI) Workshop project: "The First Symposium on Industrial Ecology for Young Professionals", *National Science Foundation*, Environmental Sustainability program, Jan 2009 - May 2009 ($37,886)

(P.I.) Research Experience for Undergraduates (REU) supplement to "Assessing and managing the sustainability of global reverse supply chains: the case of personal computers", *National Science Foundation*, Environmental Sustainability program, Jan. 2009 - Dec. 2009 ($7,000)

(senior personnel) Research project, "EFRI-RESIN: Sustainable Infrastructures for Energy and Water Supply", *National Science Foundation*, Sep. 2008 – Aug. 2011 ($1,991,498)

(joint award with Brad Allenby) Industrial Ecology Fellow, "Substitution and Complementarity of ICT products and services", *AT&T Foundation*, Jan. 2008-Dec. 2008 ($25,000)

(P.I.) Research Project, "Life Cycle Water Use of Alternative Transportation Fuels", *Arizona Water Institute*, Jan. 2008- Dec. 2008 ($20,000)

(P.I.) Research Project, "Assessing and managing the sustainability of global reverse supply chains: the case of personal computers", *National Science Foundation*, Environmental Sustainability program, Sep. 2007- Aug. 2010 ($350,000)

(co-PI) Research project, "Environmental and Economic Impacts of Material Used in Future Urban Development", *Science Foundation Arizona*, Jan. 2007-Mar. 2008 ($399,000)

(senior personnel) MUSES: Sustainable Consumption, Globalization and Information: Impacts and Opportunities, National Science Foundation, Materials Use: Science, Engineering and Society program planning grant, Sep. 2006-Aug. 2007 ($100,000)

(joint award): Industrial Ecology Fellow, "Information Technology-based monitoring and control systems to mitigate energy use in households", *AT&T Foundation*, Jan. 2006-Dec. 2006 ($25,000)

(co P.I.) Scoping research: "Environmental applications of Information Technology", *Intel*, Jun. 2005-Dec. 2005 ($6,000)

(co P.I.) Project development: "Solving the E-waste problem: a synthetic approach", *Hewlett Packard*, Apr. 2005-Mar. 2006 ($50,000)

(P.I.) Research project: "Roadmapping the adoption of energy efficient technologies in the Chinese iron/steel industry", *New Energy and Industrial Technology Development Organization (NEDO)* – Japan, Apr. 2005-Mar. 2006 ($25,000)

(P.I.) Research project: "Energy consumption of IT infrastructure in Asia - Computer Use Patterns", *New Energy and Industrial Technology Development Organization (NEDO)* – Japan, Apr. 2004-Mar. 2005 ($25,000)

(co P.I.) Research project: "Testing the theory of telescoping environmental transitions", *U.S. Environmental Protection Agency*, Mar. 2004-Aug. 2004 ($23,000)

(joint award), Industrial Ecology Fellow: "Effects of computer usage patterns on the life cycle energy consumption of IT infrastructure", *AT&T Foundation*, Jan. 2004-Dec. 2004 ($25,000)

(co P.I.) Research project: "The Digital Economy and Energy", *Japan Foundation - Center for Global Partnership*, Jun. 2001- May 2003, ($160,000)

Event co-funding: "International Symposium on Information Technology and the Environment", held Oct. 2002 in Tokyo: support from the *Japan Zero Emissions Forum* ($10,000) and *Ministry of Science and Education Committee on Zero Emissions* ($5,000).

(award) Takeda Fellowship Award for Outstanding Researchers, *Takeda Foundation*, Sep. 2001-Aug. 2002 ($40,000).

Education - Advising of graduate students

As chair of thesis committee (8 graduate students of which 5 PhD, 3 M.S.):

- Ramzy Kahhat, Civil and Environmental Engineering, ASU, PhD exam passed 2009
- Carolyn Mattick, School of Sustainability, ASU, M.S. exam passed 2009
- Yan Yang, Civil and Environmental Engineering, ASU, M.S. expected 2009
- Liqui Deng, School of Sustainability, ASU, PhD expected 2010
- Michelle Mutchek, Civil and Environmental Engineering, ASU, M.S. expected 2011
- Chris Harto, School of Sustainability, ASU, PhD expected 2011
- Robert J. Meyers, School of Sustainability, ASU, PhD expected 2011
- Pei Zhai, School of Sustainability, ASU, PhD expected 2011

As thesis committee member (4 graduate students, all PhD):

- Christopher Weber, Civil and Environmental Engineering/Engineering and Public Policy, Carnegie Mellon, PhD exam passed 2008
- Junbeum Kim, Civil and Environmental Engineering, , ASU PhD passed 2008
- Ming Xu, Civil and Environmental Engineering, ASU, PhD passed 2009
- Rajesh Buch, School of Sustainability, ASU, PhD expected 2010

Education - Courses taught

#	Dates	Course	Department/Institution
1	Spring 2009	Sustainable Consumption	School of Sustainability, Arizona State University
2	Spring 2009. Spring 2008, Spring 2007	Industrial Ecology and Design for Sustainability	Civil and Environmental Engineering & School of Sustainability, Arizona State University
3	Fall 2008, Fall 2007, Fall 2006	Engineering Business Practice	Civil and Environmental Engineering, Arizona State University
4	Spring 2005	Advanced Life Cycle Assessment	Civil and Environmental Engineering, Carnegie Mellon University
5	Spring 2004, Spring 2005	Environmental Governance	School of International Politics, Economics and Business, Aoyama University, Tokyo
6	5. 2002, 2004	International Course	United Nations University, Tokyo
7	Spring 1995	Fourier Analysis	Dept. of Mathematics, Univ. of Minnesota
8	Spring 1995	Calculus II	Dept. of Mathematics, Univ. of Minnesota
9	Fall 1994	Calculus I	Dept. of Mathematics, Univ. of Minnesota
10	Fall 1994	Pre-Calculus	Dept. of Mathematics, Univ. of Minnesota
11	Spring 1992	Classical Mechanics	Dept. of Physics, SUNY at Stony Brook
12	Spring 1991	Optics	Dept. of Physics, SUNY at Stony Brook
13	Fall 1990	Modern Physics	Dept. of Physics, SUNY at Stony Brook
14	Fall 1989, Spring 1990	Introductory Physics	Dept. of Physics, SUNY at Stony Brook

(details of teaching evaluations available on request)

Notes:

1. Upper division undergraduate course, Roles: developing course and primary instructor
2. Graduate course, Roles: developing course and primary instructor
3. Upper division undergraduate course, Role: primary instructor
4. Graduate course, Roles: developing course and primary instructor
5. Master's degree course, Role: co-developer and co-instructor
6. Intensive, one month non-accredited course, Role: guest lecturer
7. Upper division undergraduate course, Role: primary instructor
8. Lower division undergraduate course Role: head instructor of multi-section course with coordination of teaching assistants for recitation sections
9. Lower division undergraduate course, Role: head instructor of multi-section course with coordination of teaching assistants for recitation sections
10. Lower division undergraduate course, Role: head instructor of multi-section course with coordination of teaching assistants for recitation sections
11. Graduate course, Role: graduate teaching assistant
12. Lower division undergraduate course, Role: graduate teaching assistant
13. Lower division undergraduate course Role: graduate teaching assistant
14. Lower division undergraduate course Role: graduate teaching assistant

Service

Arizona State University committee membership

Department of Civil and Environmental Engineering: Member, Academic Affairs Committee, Oct. 2008 - present

School of Sustainability: Member, Executive Committee, Sept. 2008 - present

School of Sustainability: Member, Undergraduate Committee, Oct 2007- Aug. 2008

External service

Green Electronics Council, Member, Board of Councillors, March 2009-present

IEEE: Treasurer, IEEE Technical Committee on Electronics and the Environment, August 2008-present

EcoDesign 2009 Conference (Japan): Conference co-Chair, Aug. 2008- present

International Society for Industry Ecology: Member, Program Committee, 2009 Conference of the International Society for Industry Ecology, Jul. 2008 - present

IEEE: Conference Chair, IEEE International Symposium on Electronics and the Environment, May 2008, San Francisco, California

U.S. House of Representatives Committee on Science and Technology: Witness, Hearing on e-waste and Technology, Apr. 29, 2008

National Academy of Sciences: Member, Committee on Point of Use and Full Fuel Cycle Measurement Approaches to Energy Efficiency Standards, Jan. – Dec. 2008

National Science Foundation: Review Panel member, Environmental Sustainability program, December 2007

International Society for Industry Ecology: Program Committee, International Conference of the International Society for Industry Ecology, June 2007, Toronto, Canada

IEEE: Program Chair, IEEE International Symposium on Electronics and the Environment, May 2007, Orlando, Florida

IEEE: Program Co-chair, IEEE International Symposium on Electronics and the Environment, May 2005, New Orleans, Louisiana

Professional review activities for journals

Canadian Journal of Civil Engineering; Chemosphere; Energy: the International Journal; Environmental Impact Assessment Review; Environmental Science & Technology; IEEE Symposium on Electronics & the Environment; International Journal of Environment and Sustainable Development; International Journal of Life Cycle Assessment; Global Environmental Politics; Journal of Cleaner Production; Journal of Industrial Ecology; Journal of Material Cycles and Waste Management; Journal of the Air & Waste Management Association; ASCE Journal of Infrastructure Systems; Proceedings of the National Academy of Sciences; Resources, Conversation and Recycling; Sustainability Science

Invited presentations (selected)

International workshop, opening speech, "International Waste Electronics Management", Minas Gerais State Environmental Foundation, Belo Horizonte, Brazil, August 13-14, 2009

International workshop, "7th Workshop for Digital Inclusion", with advisee Ramzy Kahhat, Berem, Brazil, November 2008

International conference, "Escrap 2008", Phoenix, Arizona, September 2008

Tutorial presenter, IEEE Components, Packaging, and Manufacturing Technology Society, Phoenix, September 2008

Seminar, School of Forestry and Environmental Sciences, Yale University, September 2008

Seminar, National Institute of Advanced Science and Technology, Tsukuba, Japan, July 2008

International conference, "2008 International Computer Refurbishers Summit", with advisee Ramzy Kahhat, Toronto, Canada, May 2008

Seminar, School of Environmental Design, University of Calgary, Canada, May 2008

Congressional Hearing, "Electronic waste – Can the nation manage modern refuse in the digital age?", U.S. House of Representatives Committee on Science and Technology, Washington D.C., April 2008

Conference, "28th Annual Microcomputers in Education Conference", Phoenix, Arizona April 2008

Seminar, Department of Civil and Environmental Engineering, Carnegie Mellon University, March 2008

Seminar, Department of Energy, Environmental and Chemical Engineering, Washington University, St. Louis, February 2008

International workshop, "The Second NIES Workshop on E-waste", National Institute of Environmental Studies (NIES), Tsukuba, Japan, November 2005

International conference, "Visions of the Information Society Conference", EMPA, St. Gallen, Switzerland, November 2005

Seminar, Research Center for Eco-Environmental Sciences, Beijing Academy of Sciences, China, January 2005

Outreach: Media coverage of research (selected sampling)

Popular media Print/Web

1. Discovery Channel DiscoveryTech, "Don't recycle that computer, reuse it", July 10, 2008 (URL: http://dsc.discovery.com/technology/my-take/computer-recycle-bad.html)
2. Arizona Republic, Safe Recycling of E-Waste Is a Priority", January 25, 2008
3. Financial Times, "IT going green: Are the problems just being passed on?", July 11, 2007
4. AZ Republic, "Out with the old, but where to…", July 2, 2007
5. Financial Times, "Computer makers miss the big green picture", June 7, 2007
6. PC Magazine, "What's Inside a Laptop", April 10, 2007, p. 87-91
7. Foreign Policy, "Pollution Solution", September/October 2004, p. 92
8. WorldWatch, "Microchips are tiny, but their environmental footprint is heavy", 16(2). Mar/Apr 2003, p. 8
9. Sierra, "Little Chips, Big Impact", March/April 2003, p. 68
10. BBC, "Chips cost environment dear", Nov. 12, 2002 (URL: http://news.bbc.co.uk/2/hi/technology/2444675.stm
11. Business Week, "Microchips weigh heavily on environment", Dec. 15, 2002 (URL: http://www.businessweek.com/technology/cnet/stories/964721.htm)
12. Financial Times, "Green pressure on chips ", December 5, 2002, p. 13

Science/Engineering Print/Web

1. Chemical and Environmental Engineering News, A Tsunami Of Electronic Waste, May 26, 2008 (URL:http://pubs.acs.org/cen/email/html/cen_86_i21_8621gov1.html)
2. Environmental Science & Technology News, Reducing the global impact of e-waste, January 23, 2008 (URL: http://pubs.acs.org/subscribe/journals/esthag-w/2008/jan/tech/kb_recyclecomp.html)
3. Nature Materials, "Heavy Computing", vol. 3 no. 5, 2004, p. 287
4. Electronic Engineering Times, "Running the numbers", Mar. 22, 2004, p. 59
5. Science, "The Macro side of Microchips", Nov. 8, 2002, 298(5586), p. 1137
6. New Scientist, "Computing's dirty little secret is finally revealed", Nov. 16, 2002, 176(2369), p. 8
7. Nature, "Why microchips weigh over a kilogram", Nov.2, 2002 (URL: http://www.nature.com/nsu/021028/021028-12.html
8. Scientific American, "Making Microchips Takes Mountain of Materials", Nov. 6, 2002 (URL: http://www.sciam.com/article.cfm?chanID=sa003&articleID=0000E57E-E47B-1DC6-AF71809EC588EEDF)
9. Science News, "Hidden costs: it takes much stuff to make one tiny chip", November 16, 2002, p. 309
10. Chemical & Engineering News, "Heavy Burden of Microchips", Dec. 23, p. 25-27
11. Electronic Engineering Times, "Chips, toxics and real life", 1278, p. 81, December 2002

Radio/Television

1. Segment on National Public Radio (NPR) special ("Sustainability", aired various NPR stations in March/April 2009)
2. BBC World Service radio ("Digital Planet", Aug. 3 2008, "World Update", Mar. 8, 2004; "Go Digital, Mar 8, 2004; "World Today, Mar. 6, 2004, "Go Digital" Nov. 11, 2002)
3. Canadian Broadcasting Corporation radio ("The Current", Mar 9, 2004; "As It Happens", Nov 28, 2002)
4. National Public Radio ("Future Tense", March 11, 2004)
5. CNBC television("Tech Watch", 11:30, Mar. 10, 2004)
6. BBC television (Domestic Service, March 8, 2004)