COOK STOVES AND CLIMATE CHANGE

Steven L. Garrett
Graduate Program in Acoustics, College of Engineering
The Pennsylvania State University
University Park, Pennsylvania 16802

Scientists and engineers are victims of a significant and subtle form of discrimination. We are never made aware of the policy opportunities that are regularly afforded to those in more traditional "policy-oriented" disciplines like political science or international relations. The significance of this discrimination is societal loss of our insights into the ubiquitous scientific and engineering issues that are central to both domestic and international policy decisions. The subtlety is due to the fact that the discrimination is passive and unconscious. Many top schools in policy-oriented disciplines have "resident diplomats" who spend time on college campuses describing their experiences and making students aware of opportunities, like joining the Foreign Service, which is the branch of the State Department that provides personnel for over two hundred US Embassies and Consulates worldwide. In science and engineering schools, no such awareness is cultivated.

"As an acoustician, at this point I think I can safely say that Phil, Bill, and I were both making waves and riding waves in cook stove and climate related policymaking."

As a researcher in thermoacoustic refrigeration, my interest in science policy went back to the mid-1980s. By that time, it became clear the refrigerant gases (primarily chlorofluorocarbons or CFCs) were destroying the Earth's protective stratospheric ozone layer.[1] I found the story of the development of what became known as the Montreal Protocols,[2] as told by Ambassador Richard Benedick, the U.S. chief treaty negotiator, to be a fascinating tale of the interaction between science, commercial interests, and governments.[3] Although I found this to be interesting, I saw no way for me to be involved in such issues beyond the development of refrigeration technologies in my laboratory that did not require ozone-depleting working fluids.

My ignorance of opportunities for scientists and engineers to make contributions to the development of policy changed with the arrival of a single unsolicited e-mail message sent by a college administrator to all of Penn State's science and engineering faculty. It asked if any senior (tenured) faculty were interested in being put forward by Penn State as one of the University's two Jefferson Science Fellow nominees. The message included a link to the State Department's Jefferson Science Fellows web site[4] describing how someone like me could work (temporarily) in the State Department. In this article, I would like to recount some of my experiences as a Jefferson Science Fellow, but my overriding motivation is to make members of the Acoustical Society of America aware of the range of opportunities for them to participate in policymaking by bringing their scientific and engineering expertise, as well as their experiences as independent investigators and communicators with teaching and writing skills, to issues that are unrelated to acoustics.

In this article I will provide extensive detail on how I came to work at the State Department. These details might be useful to others, since I could never have envisioned my own transition from a "bench scientist" who had never, in sixty years, worn a suit on two consecutive days, to a science diplomat representing the nation which has claimed scientific and technological leadership throughout the second half of the twentieth century.

The Jefferson Science Fellows Program

Upon arrival at the Jefferson website, my first impression was dominated by the variety of different specialties and academic institutions represented by the twenty-four Jeffersons who had served during the first four years of the program.[5] I was particularly impressed by their distinguished international academic careers. As it turned out, one of the most enjoyable aspects of my year as a Jefferson spent living in Washington, DC, was my close and collegial interactions with the other six Jeffersons in my year-group, as well as with non-scientists who were serving in the State Department and other government agencies and non-governmental organizations. In many ways, those interactions were much closer to the ideal image I held regarding a "university atmosphere" than the actual reality of university life which tends to be dominated by so many daily responsibilities that it is nearly impossible to enjoy intellectual discourse with knowledgeable faculty members who are outside my home department.

The second feature of the Program described at that site which I found encouraging was the long duration—a Jefferson spends an entire year living in Washington, DC, and working at the State Department,[6] followed by a subsequent five-year "consultancy" commitment. Based on my experiences on university faculties and as a consultant, I know that every organization has a distinct "organizational culture" that is only revealed by living within it. If I do not understand the culture, I do not stand a chance of being effective within that organization. Again, that initial impression also turned out to be valuable, since knowledge of the State Department's organizational hierarchy, their worldwide system of embassies and consulates, and the "country desks" in Washington that are responsible for bi-directional communication with those outposts, were hard-won bits of State Department fluency that serve me well.

The Jefferson Science Fellows (JSF) Program was initiated by The Office of the Science and Technology Adviser to the Secretary of State. That office was created in response to a National Research Council's study entitled "The Pervasive Role of Science, Technology, and Health in Foreign Policy".[7] That report highlighted the attrition of scientists from the State Department at a time when the importance of science and technology was expanding in nearly every component of foreign policy.

The second person to hold the recently-created position of Science and Technology Adviser to the Secretary (STAS) was George Atkinson, a professor of chemistry and optical sciences at the University of Arizona. As a scientist, he knew that researchers were accustomed to studying a subject over a long period, yet he also understood the necessity for policymakers to make informed decisions quickly. "I began to see more clearly that these two communities (those of academic scientists and of State Department policymakers), which have long been understood to be different cultures, had to find better ways to communicate in a modern world."[8]

Atkinson initially enlisted eighteen academic institutions that agreed to provide salary and benefits to faculty members who spend a year at the State Department and convinced the MacArthur Foundation and the Carnegie Corporation to provide grants of over $2 million to the National Academy of Sciences to support the Jefferson "experiment" for its first three years of operation. Subsequent funding was taken over by the State Department upon recognition of the value of the contributions the Jefferson Fellows made to their mission. Recently, the US Agency for International Development (USAID) has also funded the program and, starting in 2009, Jeffersons are also working at USAID.

What's acoustics got to do with it?

The Jefferson Fellows selection process begins with each of the now over 125 eligible academic institutions (those that have executed memoranda-of-understanding with the State Department) nominating as many as two of their faculty members. In addition to a resume, those nominees have to submit a statement-of-interest and two essays,[9] along with three reference letters. The year I applied, eighteen of the applicants were invited to Washington to interview and shortly thereafter, seven of us were selected (see Fig. 1). Since Jeffersons are required to obtain a security clearance, my first responsibility was to complete the security paperwork and an extensive conflict-of-interest disclosure.

As you might suspect, the year in Washington is synchronized with the academic calendar, so Jeffersons start in mid-August. Our first two days were spent taking photos for badges, attending a security briefing, going to a swearing-in ceremony, and reading a three-ring binder that contains the two-page descriptions of positions for Jeffersons that various offices within the State Department and USAID have submitted. Had I not requested the binder for the previous year shortly after being selected, I would have been overwhelmed with the diversity of opportunities.

The State Department is organized into functional and regional bureaus and that structure was preserved in the job descriptions with individual bureaus listing one or more positions within specific offices. There were positions in intelligence and research; democracy, human rights, and labor; verification, compliance and implementation (*e.g.*, biological weapons treaties); international security and nonproliferation; international organizations (*e.g.*, US representation at the UN); economic and business affairs (*e.g.*, telecommunication policy or export control); oceans, international environment, and scientific affairs; as well as regional opportunities in Europe, the Western Hemisphere, and East Asia. Needless to say, "acoustics" did not appear anywhere in any position description.

New Jeffersons are given just under two weeks to arrange interviews with the originators of the position descriptions that we found attractive before each of us had to make our placement decision, assuming the office we had selected indicated to STAS that we were acceptable. The office interview process was critical, both because it gave us an opportunity to meet the people with whom we could be working if we selected that office, but also because it was a very quick and intense introduction to a significant cross-section of the offices we might be interacting with once we "settled" into our home office.

Policy is made within the State Department by a "clearance" process. Some office might initiate a policy or program, but before it is approved and implemented, it has to be "cleared" by every office that might be involved in the relevant geographical or policy areas. Although an office might simply clear a memorandum initiated by another office (possibly because that office had already been involved in the

Fig. 1. Six of the seven 2008-2009 State Department Jefferson Science Fellows. (Left to Right): Philip Hopke, Bayard D. Clarkson Distinguished Professor, Director, Institute for a Sustainable Environment, and Director, Center for Air Resources Engineering and Science, Clarkson University; Timothy DeVoogd, Professor, Department of Psychology, Neurobiology and Behavior, Cornell University; the author; Robert Butera, Professor, School of Electrical and Computer Engineering, Laboratory for Neuroengineering, Georgia Institute of Technology; Mohammed Zikry, Professor, Department of Mechanical and Aerospace Engineering, North Carolina State University; and Michael El-Batanouny, Professor of Physics, Boston University. Not shown is Steven Geary, Professor and Department Head, Department of Pathobiology & Veterinary Science and Director, Center of Excellence for Vaccine Research, The University of Connecticut.

drafting of that policy), frequently an office will respond to the memorandum with recommendations that need to be considered before providing clearance. Going through the two-week interview process gave each new Jefferson exposure to a variety of such offices, and their personnel, which ultimately made it a little easier to operate within that system that functions by consensus.

The final decision regarding which Jefferson would go to which office was made in the Jefferson Room of the Ralph Bunche Library. That room contains treaties and other diplomatic artifacts that go all the way back to the days when Thomas Jefferson was our country's first Secretary of State. It was at that moment that I was struck with the seriousness of the responsibility I had assumed by allowing myself to become part of the United State's primary international diplomacy apparatus.

The Office of Regional and Security Policy Affairs (EAP/RSP)

The office in which I served during my year in DC as Senior Science Advisor, and for which I am now serving as a consultant, is the Office of Regional and Security Policy Affairs within the Bureau of East Asian and Pacific Affairs (EAP/RSP). I was interested in that position for several reasons. That office has primary responsibility for the US relations with the ten members[10] of the Association of Southeast Asian Nations (ASEAN). ASEAN was very attractive to me because of the variety of cultures and political systems (not to mention cuisines!) that were represented, ranging from the world's largest Muslim-majority nation (Indonesia) to the small and prosperous city-state of Singapore. It includes long-time US allies like Buddhist-majority Thailand and the Catholic-majority Philippines, as well as communist countries and former adversaries (Viet Nam and PDR Laos) and Burma (Myanmar), a military dictatorship which presents many current diplomatic challenges. It also appeared to me that ASEAN was similar in many ways to the European Common Market that was the precursor to the European Union, since those ten countries had different languages and a history of armed conflict, but also had common political and economic interests that were strongly influenced by their geographical (though not cultural!) proximity to both India and China (hence, their former designation as Indochina).

I was also attracted by the variety of different specialists that were working in EAP/RSP. There was one Foreign Service officer with responsibility for congressional relations who had just rotated out of Afghanistan and another who concentrated on human rights issues and trafficking in persons. There was also an exchange officer from the Japanese Foreign Ministry (their equivalent of our State Department) and a colonel detailed to that office from the US Army who focused on regional military issues.

Each office is led by a Director and Deputy Director. EAP/RSP also already had one Science Advisor. Most of my interview time was spent talking with Phil Antweiler, the Deputy Director, and William Behn, their Senior Science Advisor. Both struck me as being extraordinarily competent and very intelligent. As I discovered long after the interviews, Antweiler was a former academic, and like many in the Foreign Service, made the State Department a mid-career choice. Bill Behn was serving in that office as an IEEE Policy Fellow. He was about my age and had worked at Rand Corp., was a licensed patent agent, and had spent twenty years working for Hewlett-Packard. Prior to coming to State, he worked in Congress. It seemed to me that both our backgrounds and our styles were complementary and that the two of us, both working as Senior Science Advisors in EAP/RSP, could be much more effective than either of us working alone. Those assessments turned out to be among the best I've made during my entire career, which has been built on the ability to quickly recognize talent.

Getting down to work

Within EAP/RSP, Jack Andre, a retired Foreign Service officer, was *the expert* on ASEAN. Like any academic, I asked him to recommend reading that might provide some useful background. He recommended a variety of materials from reports produced by the Congressional Research Service on US relations with individual countries in the region[11] and on East Asian regional architecture,[12] articles on strategy,[13] recent speeches by regional leaders,[14,15] international diplomatic agreements,[16] and relevant ASEAN documents.[17,18] (Fortunately, the official language of ASEAN is English.) I consumed hundreds of pages over the long Labor Day weekend and returned to Jack's office with several questions based on my reading. After answering all of my questions (as well as addressing the misunderstandings that motivated some questions), I asked what I should read next. His answer came as a shock to a physicist, since our training requires years before we are empowered to attempt anything "original". Jack said, "That's it; time to hop in."

My first "official assignment" was to assess the value of having the U.S. become a partner in the ASEAN University Network. Given my academic credentials, this seemed perfectly reasonable. I was told that I was also expected to use my expertise to determine the most diplomatically important issue affecting the ASEAN region in which U.S. science and technology could have a significant and positive impact. "Time to hop in" indeed!

Even to one as inexperienced in diplomatic matters as I was, by late-2008 it was fairly clear that the most important global scientific issue facing the State Department was climate change mitigation and adaptation. Fortunately, I had the wise counsel of my Jefferson colleague, Phil Hopke. He is a professor at Clarkson and a Princeton-trained nuclear chemist who focused his career on atmospheric aerosols. Phil was a co-founder of the American Association for Aerosol Research and was the oldest Jefferson in our year group. By the time I met Phil, he had published over 400 referred journal articles, over 700 conference presentations, and directed 47 M.S. and 30 Ph.D. theses. He had served on several National Academy committees and did so much work for the Environmental Protection Agency that he had an EPA access badge. Phil told me that carbon dioxide was actually neither the most significant climate forcer in South and Southeast Asia and sub-Saharan Africa, nor necessarily the best target

for remediation. He provided my second major reading assignment during that first month in EAP/RSP, starting with the review article by Ramanathan and Carmichael on "Global and regional climate changes due to black carbon",[19] an analysis of an atmospheric phenomenon known as the "Asian Brown Cloud" and its consequences.

Biomass burning cook stoves, indoor air pollution, and health

Before taking this story any further, I must comment on the importance of the revolution in research that has been enabled by the instant access to information provided by the internet. Fortunately, I do not have to imagine how I could have familiarized myself with these issues, all quite far from my areas of expertise, if I did not have State Department and Penn State University on-line journal access and if all of the government and non-governmental organization reports were not available in electronic form on-line. It certainly levels the playing field for scientists and engineers entering policy arenas that are dominated by those who specialize in international relations.

When I started my investigation into the sources of black carbon (soot), the commonly accepted understanding of the ratio of atmospheric black carbon due to biomass burning, primarily from cooking, vs. other sources (*e.g.*, diesel exhaust), was about 50/50. An excellent subsequent study used neutron-activation analysis to demonstrate that 75% of Asian atmospheric black carbon was due to biomass burning[20] that includes cooking as well as forest fires (both natural and man-made). The World Health Organization (WHO) cataloged the percentage of the population that used solid fuels in each country.[21] Like the U.S., solid fuels were used by less than 5% of the population of Singapore and Malaysia, but nearly half of Filipinos cooked with solid fuels, over 70% of Thais, Indonesians, and Vietnamese, while Lao PDR, Cambodia and Burma were all over 95% biomass burners. Clearly, this was an ASEAN problem and that made it my problem.

The good news is that the atmospheric lifetime of black carbon is only about ten days. That means that if it is not generated, then the significant contribution of soot to global warming stops rather abruptly.[22] By contrast, the atmospheric lifetime of anthropogenic CO_2 is complicated (the sum of terms with different time constants[23]), but the long-time tail is probably about 30,000 to 35,000 years.[24] Reduction in the production of CO_2 will not reduce temperature on multi-century timescales, but only reduce its rate of increase—most of what is already in the atmosphere stays there essentially forever. Other non-CO_2 climate forcers have lifetimes that are also significantly longer than black carbon: CH_4 (12±3 years), N_2O (114 years), CFC-12 (100 years), HCFC-22 (12 years).

WHO data also demonstrated that biomass soot was not just an issue that impacted global climate change, but also was a public health problem with a magnitude that was comparable to HIV/AIDS, malaria, malnutrition, and disease related to availability of clean drinking water or lack of sanitation. The WHO ranks harmful cook stove smoke as the fourth worst overall health risk factor in developing countries. Estimates put smoke inhalation as the cause of 1.9 million premature deaths annually, with women and young children the most directly affected. Inefficient cook stoves increase the risk of acute respiratory tract infections in children younger than five years and chronic respiratory and heart disease in adults older than 30 years. Globally, almost 1 million children are currently dying every year of respiratory infections induced or exacerbated by the inefficient burning of solid fuels.[25] Cook stove smoke also contributes to a range of chronic illnesses and acute health impacts such as early childhood pneumonia, emphysema, cataracts, lung cancer, bronchitis, cardiovascular disease, and low birth weight.[26]

Reliance on biomass for cooking and heating also increases pressures on local natural resources (*e.g.*, forests, habitat) and forces women and children to spend many hours each week collecting wood. Women and girls also face severe personal security risks as they forage for fuel from refugee camps and in conflict zones.

This combination of global climate effects, local health consequences, deforestation, and violence against women suggests that a rather large constituency could be built to support a policy that would encourage the development and large-scale deployment of improved cook stoves. It seemed that the technological challenges to the design of clean-burning cook stoves could be addressed scientifically, and some such efforts were already underway, but the scale required to make a significant impact is truly daunting. Three billion

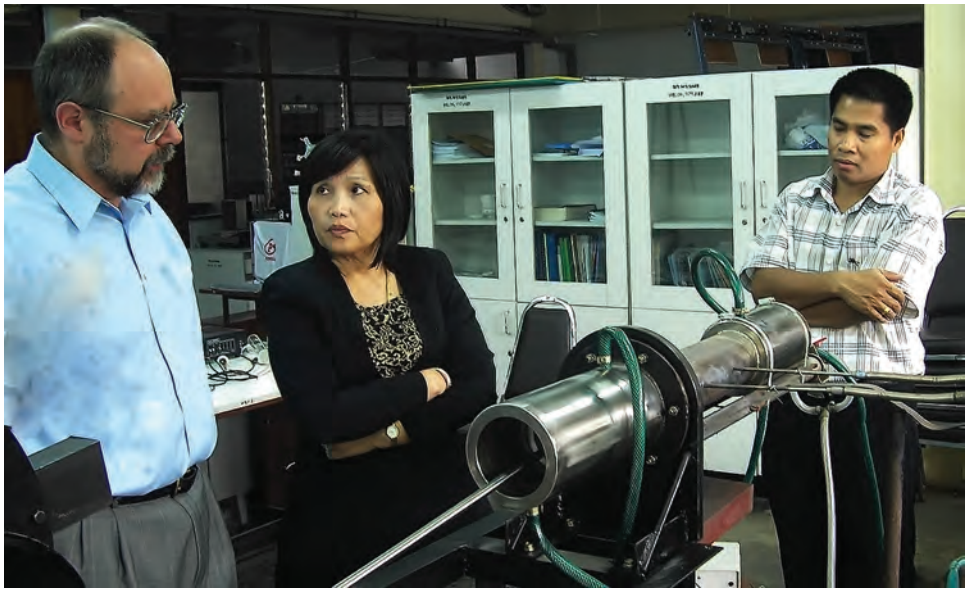

Fig. 2. The author visits a thermoacoustics laboratory at the Sustainable Energy Research Center located at Phranakhon Rajabhat University in Bangkok, Thailand. At the center of the photo is Professor Woranuch Jangsawang and at the right is her graduate student, Surachai Supperm. One year after that visit, Jangsawang and Supperm had successfully constructed and tested a clone of the Ben & Jerry's thermoacoustic ice cream chiller.[50]

people cook with biomass on roughly 600 million stoves (not stoves really, but small open fires with three stones on which to balance a pot). If the average lifetime of an improved cook stove is 3 years, then an industry capable of producing and distributing 200 million cook stoves each year would be required. In 2009, roughly 100 million cell 'phones were produced worldwide.

From research toward the development of a policy consensus

Nobody at the State Department was interested in cook stoves when my group of Jeffersons arrived in fall of 2008. There was work related to distribution of stoves in refugee camps that had been tried by the US Agency for International Development, but their experience with attempts to provide "improved" stoves was not encouraging. One USAID study of "improved" cook stoves provided by NGOs as part of a humanitarian relief effort for residents of internally displaced-persons camps in the westernmost region of Sudan (Darfur) found the following: "Stove performance tests conducted by the evaluation team revealed that one stove consistently seemed to consume significantly less fuel than the traditional three-stone fire; several performed slightly better or slightly worse than the three-stone fire; and one stove consistently consumed more fuel than the three-stone fire. Fuel efficiency did not increase proportionately with the cost/design sophistication of the stoves tested."[27] With the exception of China, improved cook stove projects in other countries were also judged to be failures.

By October 2008, there seemed to be several pathways to address the portion of this problem that might involve the U.S. and ASEAN. I was fortunate that there were two circumstances that made the next steps happen very quickly: The first was that ASEAN has a Committee on Science and Technology which includes a Sub-Committee on Non-Conventional Energy Research (SCNCER). The second was that the Jefferson program included funds for Fellows' travel related to their State Department activities.

SCNCER facilitated immediate identification of individuals in each member country who could provide me with guidance regarding the interest in improved cook stoves within ASEAN and who could comment on the potential value of a workshop I was contemplating to assess the current state of improved cook stove development and to scope the opportunities for improvement. U.S. embassies were able to set up meetings for me with SCNCER country representatives J.C. Ho (Singapore), P. Sardjono (Indonesia), and H. Mokhtar (Malaysia), as well as with Prof. N. T. Kim Oahn, a Vietnamese national teaching at the Asian Institute of Technology (Bangkok). She agreed to host the Workshop and showed me her cook stove lab and the excellent (and affordable) conference facilities and campus housing (hotel) accommodations.

I spent an entire month in Southeast Asia during that first trip and had the opportunity to visit the ASEAN University Network Secretariat at Chulalongkorn University in Bangkok as well as visit and present technical colloquia on thermoacoustics as part of the State Department's "public diplomacy" efforts (see Fig. 2). These academic visits were enjoyable for me since there is a natural camaraderie among academics that was not part of official visits to government agencies. It also provided the embassy personnel who accompanied me with access to those academic institutions. I met with members of the ASEAN Secretariat in Jakarta, and officials in various science and technology related government agencies that are similar to our National Science Foundation in four countries. I learned about their interests and research infrastructure and solicited their reaction to a cook stove workshop.

I was also fortunate during the same trip to be a member

of the U.S. delegation to the 10th ASEAN-U.S. Informal Coordinating Mechanism Meeting that brings together delegations from all ten ASEAN countries to review progress in ASEAN-U.S. relations and to prioritize future collaborative efforts. That meeting was co-chaired by Jacky Foo, the Director-General of the ASEAN Secretariat, from the Ministry of Foreign Affairs of Singapore, and by Scot Marciel, a Deputy Assistant Secretary of State and then U.S. Ambassador for ASEAN Affairs who later became the U.S. Ambassador to Indonesia. For the most part, I sat silently and marveled at the skill of these two professional diplomats who were able to guide all of the parties from eleven different countries to work together efficiently while maintaining a congenial atmosphere.

Our embassies were very efficient and would typically schedule as many as three official visits every day in different locations. I would be accompanied by a local driver, a "foreign national" working for the U.S. embassy who could act as a translator, and usually at least one other U.S. embassy official in addition to the embassy's Environment, Science, Technology and Health Officer. My weekends were free and that gave me the opportunity to roam around many fascinating Southeast Asian cities on my own.

That trip also exposed me to the crisis management functions performed by the American Services component of our embassies. While in Thailand, political protestors closed both of Bangkok's airports. I was asked to staff the telephone banks that were providing information to stranded U.S. citizens. Eventually, I was able to continue my trip by traveling three hours by car from Bangkok to Pattaya, on the Gulf of Siam, and flying out of U-Tapao, a former Viet Nam era U.S. Air Force base that now serves as a joint civil-military public airport.

I returned to Washington, DC, in December and in January attended an annual cook stove conference near Seattle, WA, that was organized by Engineers in Technical and Humanitarian Opportunities of Service (ETHOS). The ETHOS Conference brings together academics, representatives of NGOs involved in cook stove development, testing, and dissemination, as well as many independent folks who develop stoves by trial-and-error with little theoretical guidance in their own garages. By February, I was starting to feel as though I had a pretty good handle on the issues, much of the technology, and the most significant players.

Seminars, an International Cook Stove Workshop, and the *Research Road Map*

Other than the specific source materials (*i.e.*, no JASA articles!), the research phase described thus far is not significantly different from what we ordinarily do when we address an acoustical research topic. It should come as no surprise that the education and consensus-building phase of policy-making is also similar.

Of course, the first activity always involves writing some document. Since the Jefferson Program is run by STAS, the format of this first exercise was the "Mini-Briefing". That is a two-page summary that was preferred by Dr. Nina Fedoroff, a very well-respected plant geneticist, molecular biologist, and science diplomat[28] who was the Science and Technology Adviser to the Secretary of State and to the Director of the U.S. Agency for International Development from 2007 through 2010. She is currently the president of American Association for the Advancement of Science. Dr. Fedoroff would occasionally brief the Secretary of State and liked to provide that two-page mini-briefing to the appropriate members of the Secretary's staff.

Having identified the various stakeholders in the related areas of climate, health, and household energy within the executive branches of the U.S. government (*e.g.*, Department of Energy, DOE; Environmental Protection Agency, EPA; National Institutes of Health, NIH; United States Agency for International Development, USAID; Office of Management and Budget, OMB, and several offices within the State Department), Non-government Organization, NGOs (*e.g.*, UN Foundation, ETHOS, Earthjustice, World Bank, Deutsche Gesellschaft für Technische Zusammenarbeit,

Fig. 3. (Left–to-Right) Prof. Alexis Belonio, Director, Appropriate Technology Center, Central Philippine University, Iloilo City; the author; Phil Hopke; and Bill Behn; at the ASEAN-U.S. Next-Generation Cook Stove Workshop held at the Asian Institute of Technology in Pathumthani, Thailand. In the foreground is the rice-husk burning "fan stove" that was recognized by the Rolex Award for Enterprise (2008 – Environment Category). The fan and electronic fan control is visible at the base of Prof. Belonio's stove. [Photo credit: Rolex Awards/Kirsten Holst.]

Worldwatch Institute, Winrock, etc.), and both an established and nascent appliance manufacturing base (*e.g.*, Philips, Bosch, BP, Shell, Aprovecho, Envirofit, WorldStove, First Energy, etc.), Phil, Bill and I arranged two seminars held at State in April 2009. As you might imagine, an invitation to a seminar at the State Department sent by a "Senior Science Advisor" will generate a larger and more positive response than an invitation from a mere academic. The first seminar was introduced by Dr. Fedoroff and featured Dr. Mark Bryden, the president of ETHOS. The second featured Prof. Kirk Smith, Professor of Public Health at the University of California, Berkeley. Both had been involved in cook stove research and related issues for over a decade.

The seminars were very useful in focusing the attention of the State Department on the policy opportunities that a cook stove improvement program could provide. It also identified Phil, Bill and me as cook stove points-of-contact for other interested offices within State and other agencies.

One value of working in Washington, DC, was apparent during the next phase of this effort. It focused on the creation of the cook stove workshop we wanted to hold in Southeast Asia to bring together an international mix of experts who could characterize the current state-of-the-art and collaborate to identify the way that science and technology could improve cook stove performance, measure the effectiveness of those improvements, and open the way to creation of an industry that could distribute 200 million stoves each year. Every U.S. government agency which might contribute to the workshop had its headquarters in DC, as did many NGOs. The excellent subway system (i.e., the "DC Metro") made it possible to get around the greater Washington area to hold face-to-face meetings with potential workshop participants and potential sponsors. For some of the most relevant agencies, such as NSF, DOE, USAID, EPA, the UN Foundation, and the World Bank, we would typically arrange several (as many as six!) meetings at each of those agencies within that one year.

The ASEAN-U.S. Next Generation Cook Stove Workshop was actually held in November 2009, a few months after I had completed my one year of residence in DC. We were fortunate to generate financial support for the Workshop that included over ninety registered participants plus a variety of students from both the Asian Institute of Technology (AIT) and other Thai universities in the vicinity of Bangkok. The participation of many Americans was funded the National Science Foundation's Office of International Science and Technology and many ASEAN participants were funded by State Department Foreign Assistance Funds. About a third of the participants were self-funded and the Asian Office of Aerospace R&D (Tokyo) of the U.S. Air Force Office of Scientific Research provided funds directly to AIT for their support services. In addition to the US, other countries represented at the workshop included Brazil, Cambodia, Canada, China, Egypt, India, Indonesia, Malaysia, Nepal, the Philippines, Singapore, Swaziland, Thailand, and Viet Nam. Figure 3 shows the workshop organizers with Alexis Belonio from the Philippines, who developed a clean-burning rice-husk stove. Papers were presented in sessions that covered the current state-of-the-art, stove characterization and testing, combustion and fuels, utilization of stove waste heat for electrical co-generation, sensor needs, scale-up, and design for large-scale deployment. There were also several "break out" sessions to which each participant was assigned to discuss the session topics and then present the results of those discussions to all other participants.

The *Research Road Map*, a report that Phil, Bill and I co-authored summarizing the Workshop's findings was published in March 2010.[29] Although the production of a 48-page report required a significant effort, such a detailed document was important to nucleate action by other U.S. government agencies and the UN Foundation, focus efforts on the relevant scientific and technological issues, and provide an economic justification for the required investment.

Cum hoc ergo propter hoc (Correlation does not imply causation)

It will never be possible to determine accurately the impact of the work that Phil, Bill, and I did to stimulate policies and programs that support the development and deployment of improved cook stoves. Although we were the first to promote this issue within the State Department, it was clear that the issue was gaining visibility within the foreign policy community through the simultaneous efforts of many others as well. A very good article appeared in *The Economist* while I was in Malaysia,[30] and the following year, Wallack and Ramanathan published an article on "The Other Climate Changers" in *Foreign Affairs*.[31]

It is true that Secretary Clinton announced the creation of the UN Foundation's *Global Alliance for Clean Cook Stoves* during the (Bill) Clinton Global Initiative[32] at their annual meeting in New York City on September 21, 2010, which coincides with the opening of the UN General Assembly. It is also true that the State Department now hosts the Cook Stove Interagency Working Group (CIWG) that is charged with the coordination of all U.S. government agency participation in the UN Foundation's *Global Alliance*, and that Jacob Moss, formerly the head of the Environmental Protection Agency's Partnership for Clean Indoor Air, has moved to the State Department to head the CIWG. Bill and I continue providing our input as members of CIWG and I continue to serve as a member of the *Global Alliance's* Technology and Fuels Working Group. I have to admit that these facts do demonstrate a major change in the State Department's involvement from 2008 to 2010 and I like to think that Phil, Bill, and I played an significant role in that transformation.

You also cannot underestimate the influence of lucky coincidence in policymaking. The current Chief Science Officer for the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy (DOE/EERE) is Dr. Samuel F. Baldwin. After receiving his Ph.D. in Physics, Baldwin went to West Africa and worked on cook stove improvements. That experience resulted in him writing a 300-page manual entitled *Biomass Stoves: Engineering Design, Development, and Dissemination*.[33] It applied basic thermodynamic and heat transfer science to this problem and has been translated into French, German, Italian, Portuguese and

Spanish. Dr. Baldwin attended the ASEAN-U.S. Workshop and hosted his own *DOE Biomass Cookstoves Technical Meeting* in January 2011 in Arlington, VA,[34] to initiate a five-year, $12.5M program to address the technical barriers to the development of low emission, high-efficiency cook stoves. Needless to say, having Dr. Baldwin in a senior position within the Department of Energy was crucial to their ability to apply the considerable infrastructure of the DOE to this issue. It also appears that the National Science Foundation will be targeting an effort in this area under a recently announced NSF-Wide Investment Area entitled "Science, Engineering and Education for Sustainability[35]" that may represent as much as 15% of the NSF program investments.

As an acoustician, at this point I think I can safely say that Phil, Bill, and I were both making waves and riding waves in cook stove and climate related policymaking.

You have passed this test

This is a rather long article. If you have read all the way up to this point, you probably have a (latent?) interest in the application of science and technology to policymaking. The Jefferson Science Fellows program is small and focuses on a rather specialized (fairly geriatric) group: tenured senior faculty. It is not the only way to enter the national policymaking process. A similar State Department program, called the Franklin Fellowship Program, is directed toward recruitment of mid- to upper-level professionals (quasi-geriatric) from both private-sector and non-profits with a broad range of backgrounds and experiences, not just scientist and engineers.[36] I am even aware of one case where one spouse was a Jefferson and the other a Franklin with both spending the year together in Washington, DC.

The largest and oldest program that brings scientists and engineers into both the legislative and executive branches of the Federal government is the American Association for the Advancement of Science's (AAAS) Science and Technology Policy Fellowship Program. The AAAS, founded in 1848, is the world's largest general scientific society and the publisher of the weekly *Science* magazine, which has the largest paid circulation of any peer-reviewed general science journal in the world. Starting in 1973, the AAAS has sponsored a program that has placed over 2,000 scientists and engineers in temporary positions within the Federal government.[37] Many of the AAAS Fellows are fresh from graduate school, although there are a significant number of mid-career professionals who enter their program. In 2008, 163 Fellows were brought into the program with 130 going to the Executive Branch and 33 going to Congress. Their ages ranged from 26 to 66, with equal numbers of females and males.[38]

Unlike the Jefferson and Franklin programs (so far), many of the AAAS Fellows spend several years in the program and then remain in government service. After nearly forty years, many of the former AAAS Fellows have reached high levels. Congressman Rush D. Holt, who received a Ph.D. in Physics, got his start in policymaking as AAAS Congressional Fellow (1982-83) serving in the office of Congressman Robert Edgar (D-PA) and was an arms control expert at the State Department before deciding to run for the congressional seat he has held since 1999.

In addition, several professional societies sponsor AAAS Fellows. Among them are the Acoustical Society of America, the American Physical Society,[39] and the American Society of Mechanical Engineers, and the Institute of Electrical & Electronic Engineers.[40] Sam Baldwin was an AIP/APS Congressional Fellow (for Senator Paul Tsongas) the year prior to Rush Holt's AAAS service and, as mentioned earlier, Bill Behn was an IEEE Policy Fellow.

Epilogue – Maybe acoustics does have something to contribute to cook stoves

Many researchers have demonstrated that fan-assisted enhanced convection can substantially reduce biomass-burning cook stove emissions, reduce fuel consumption, and provide some control over the stoves heating power (known as the "turn-down ratio").[41,42] Today, there are several commercially available "fan stoves," most notably the Philips Woodstove™ and the First Energy (formerly BP) Oorja,™ that requires processed fuel pellets. Both stoves require electricity

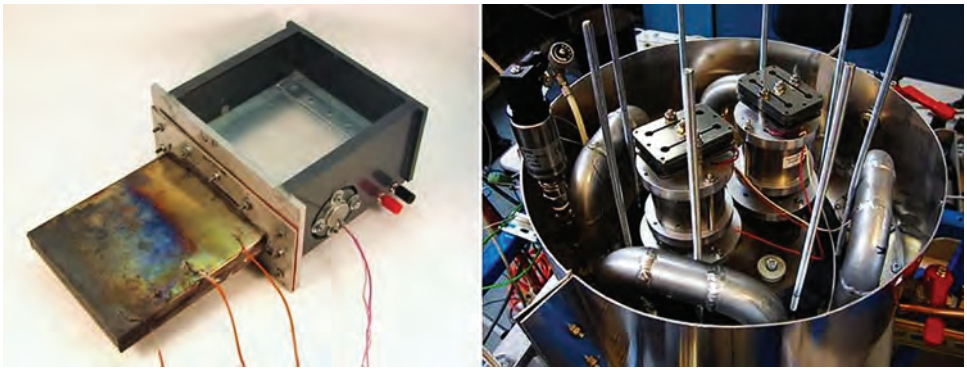

Fig. 4. Two prototype proof-of-concept thermoacoustic electrical generators designed to extract a small amount of heat from biomass-burning cook stove to generate electricity in villages that do not have access to electricity. (Left) Development of this prototype was supported by the P. S. Veneklasen Research Foundation (www.veneklasenresearchfoundation.org) and used a ceramic stack in a standing-wave thermoacoustic engine to drive a commercial 4" electrodynamic speaker using air at atmospheric pressure and electromagnetic radiation to transport heat from the stove to the hot-end of the stack.[48] (Right). A more sophisticated traveling wave thermoacoustic engine constructed by Aster, in the Netherlands uses four regenerators and 8 heat exchangers to convert heat of a stove into electricity. This one is designed to produce 50 watts of electric power. The Fuels from Agriculture in Communal Technology (FACT) Foundation is supporting this effort (www.fact-foundation.com)

to run the fan.[43] Of the 3 billion users of biomass-burning stoves for cooking, the majority do not have access to electricity.

Cook stoves typically produce between 4 kW and 8 kW of heat and a properly-designed convection-enhancement fan would typically consume less than 2 watts of electrical power. Obviously, it does not take too much imagination to realize that a small heat engine could convert a small amount of that heat to electricity. Although rather inefficient and not well-suited to the available temperatures ($T_{hot} \gtrsim 800$ °C), recent attempts have been made to run a fan from electricity generated by a thermoelectric module.[44,45] There have been other approaches using steam generation,[46,29] but recently there has been considerable activity and some preliminary successes with thermoacoustic co-generation.[47-49] Figure 4 shows two prototype thermoacoustic engines that use electrodynamic linear alternators to generate electricity from cook stove waste heat.

Acknowledgements

I owe much to my good friend, Greg Swift, in many areas, but if it were not for his stories about his participation in the revision of K-12 Science Standards for the State of New Mexico, I might never had the confidence to follow up on that fateful e-mail message soliciting volunteers for the JSF Program. Similarly, the late Henry Bass's service in implementation of the Comprehensive Nuclear-Test-Ban Treaty (CTBT) was also an inspiration that nudged me toward my State Department service. As indicated in the text, I am grateful for the insights that Bill Behn brought to the policy issues and the encyclopedic knowledge regarding climate and many other topics that Phil Hopke shared with both generosity and a wonderful sense-of-humor. I also appreciate the international diplomatic experience that Phil Antweiler was willing to share with me and Bill, as well as his uncanny ability to anticipate issues and "data calls" that would arise two weeks in advance of them being brought up by others.

Both Nina Fedoroff, and her deputy, Andrew Reynolds, provided encouragement and brought visibility for the cook stove issues to the highest levels within the State Department and USAID. I am also indebted to Dr. Myra McAulifee, Program Manager for the East Asian and Pacific Program, within the Office of International Science and Engineering at the National Science Foundation, for her help in producing the Workshop proposal and to Dr. Ken Goretta, Director of the Asian Office of Aerospace Research & Development, at the Air Force Office of Scientific Research for his enthusiastic support of the Workshop. Assistance provided by Timothy Buehrer, Chief of Party, and his staff at the ASEAN-US Technical Assistance and Training Facility, in Jakarta, was essential in providing transportation for Workshop participants.

Finally, I would like to thank the Veneklasen Foundation for their support of my research on the application of thermoacoustics to cook stove electrical co-generation.AT

References

1 M. J. Molina and F. S. Rowland, "Stratospheric sink for chlorofluoromethanes: Chlorine atom catalyzed destruction of ozone," *Nature* **249**, 810–814 (1974).

2 *Montreal Protocol on Substances that Deplete the Ozone Layer*, United Nations Environmental Programme (UNEP), New York, 1987.

3 R. E. Benedick, *Ozone Diplomacy: New direction in safeguarding the planet* (Harvard Univ. Press, 1991); ISBN 067465000X.

4 Information regarding the Jefferson Science Fellows program can be found at either the State Departments web site: http://www.state.gov/g/stas/fi/c28280.htm, or at the National Academy of Sciences web site: http://sites.nationalacademies.org/pga/jefferson/.

5 Short biographies of all Jefferson Science Fellows are available at the National Academies' web site: http://sites.nationalacademies.org/PGA/Jefferson/PGA_046613.

6 Recently, the Jefferson Program has expanded to include the possibility of Fellows serving in the US Agency for International Development (USAID). A profile of Alex Dehgan, the Science Adviser to USAID, by David Karmer, appears in *Physics Today*, pp. 30–31 (Dec 2010).

7 The Committee on Science, Technology, and Health Aspects of the Foreign Policy Agenda of the United States, Office of International Affairs, National Research Council, *The Pervasive Role of Science, Technology, and Health in Foreign Policy: Imperatives for the Department of State*, (National Academy Press, Washington, 1999). http://books.nap.edu/openbook/php?isbn=0309067855.

8 Joyce Baldwin, "Jefferson Science Fellows: A vision for harnessing the knowledge of academic scientists to help inform U.S. policymaking takes shape," *Carnegie Results* (Carnegie Corp. of New York, 2010); http://carnegie.org/fileadmin/Media/Publications/jefferson_science_fellows_carnegie_results_summer_10_extra.pdf.

9 Each essay is limited to two pages. One requires description of three major advances in the applicant's area during the past ten years that have had significant societal impact on an international scale, along with a discussion of the positive and negative aspects of the impacts, and an assessment of how effective the scientific community has been in providing information required to permit policy makers to make informed decisions. The other essay asks the nominee to identify one or more issues in science and technology that have not received sufficient attention by U.S. foreign policy makers and to describe steps that should be taken by scientists and policy makers to better address these issues.

10 The ten members of ASEAN are Brunei Darussalam, Burma (Myanmar), Cambodia, Indonesia, Lao PDR, Malaysia, the Philippines, Singapore, Thailand, and Viet Nam.

11 M. F. Martin, U.S.-Malaysian Relations: Implications of the 2008 Election, Congressional Research Service Report RL33878 (3 Apr 2008).

12 D. K. Nanto, East Asian Regional Architectures: New Economic and Security Arrangements and U.S. Policy, Congressional Research Service Report RL33653 (4 Jan 2008).

13 M. J. Green and D. Twining, "Democracy and American Grand Strategy in Asia: The Realist Principles Behind an Enduring Idealism," Contemporary Southeast Asia **30**, 1–28 (2008).

14 Transcript of Prime Minister Kevin Rudd's speech to the Asia Society Australasia (5 June 2008).

15 Transcript of the Interview with Minister for Foreign Affairs

(Singapore), George Yeo, at the 13th ASEAN Summit (15 Nov 2007).
16 Framework Document for the Plan of Action to Implement the ASEAN-U.S. Enhanced Partnership (Kuala Lumpur, Malaysia, 27 July 2006).
17 The ASEAN Secretariat, ASEAN Plan of Action on Science and Technology 2007-2011 (Jakarta, Indonesia, 2007): ISBN 978-979-3496-55-9.
18 The ASEAN Energy Cooperation, Final Report of the 14th Annual Meeting of the Renewable Energy Sub-Sector Network (Phnom Phen, Cambodia 29-31 May 2007).
19 V. Ramanathan and G. Carmichael, "Global and regional climate changes due to black carbon," Nature Geosciences **1**, 221-227 (2008).
20 Ö. Gustafsson, *et al.*, "Brown Clouds over South Asia: Biomass or Fossil Fuel Combustion?" Science **323**, 495–498 (2009).
21 *Indoor Air Pollution: National Burden of Disease Estimates*, World Health Organization Report WHO/SDE/PHE/07.01 rev (Geneva, 2007).
22 Tami Bond, Testimony for the Hearing on Black Carbon and Climate Change, U.S. House Committee on Oversight and Government Reform 2-3 (October 18, 2007); http://oversight.house.gov/images/stories/documents/20071018110647.pdf.
23 T. Barker, I. Bashmakov, L. Bernstein, J. E. Bogner, P. R. Bosch, R. Dave, O. R. Davidson, B. S. Fisher, S. Gupta, K. Halsnæs, G.J. Heij, S. Kahn Ribeiro, S. Kobayashi, M. D. Levine, D. L. Martino, O. Masera, B. Metz, L. A. Meyer, G.-J. Nabuurs, A. Najam, N. Nakicenovic, H. -H. Rogner, J. Roy, J. Sathaye, R. Schock, P. Shukla, R. E. H. Sims, P. Smith, D. A. Tirpak, D. Urge-Vorsatz, D. Zhou, 2007: "Technical Summary" in: *Climate Change 2007: Mitigation. Contribution of Working Group III to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [B. Metz, O. R. Davidson, P. R. Bosch, R. Dave, L. A. Meyer (eds.)], Cambridge University Press.
24 D. Archer, "Fate of fossil fuel CO_2 in geologic time," J. Geophys. Res. **110**, C09S05 (2004); DOI10:1029/2004JC002625.
25 P. Wilkinson, *et al.*, "Public health benefits of strategies to reduce greenhouse-gas emissions: household energy," The Lancet **374**(9705), 1917–1929 (2009); published on-line, 25 Nov 2009, DOI:10.1016/S0140-6736(09)61713-X.
26 http://cleancookstoves.org/overview/issue/.
27 *Fuel-Efficient Stove Programs in IDP Settings – Summary Evaluation Report, Darfur, Sudan*, U.S. Agency for International Development (December, 2008).
28 N. V. Fedoroff, "Science Diplomacy in the 21st Century," Cell **136**, 9–11 (2009).
29 S. L. Garrett, P. K. Hopke, and W. H. Behn, *A Research Roadmap: Improved Cook Stove Development and Deployment for Climate Change Mitigation and Women's and Children's Health* (U.S. State Department, Bureau of East Asian and Pacific Affairs, 2010). An electronic version of this report is available at the Partnership for Clean Indoor Air's web site: http://www.pciaonline.org/files/CookStoveResearchRoadMap.pdf.
30 The Economist Technology Quarterly **389**(8609), pp. 3-4 (6 Dec 2008).
31 J. S. Wallack and V. Ramanathan, "The Other Climate Changers: Why Black Carbon and Ozone Also Matter," Foreign Affairs **88**(5), 105–113 (2009).
32 http://cleancookstoves.org/blog/release-secretary-clinton-announces-global-alliance-for-clean-cookstoves/.
33 S. F. Baldwin, *Biomass Stoves: Engineering Design, Development, and Dissemination*, (Volunteers in Technical Assistance, 1987); ISBN 0-86619-274-3. http://www.aprovecho.org/lab/images/stories/camp08/ BiomassStoves.pdf.
34 Biomass Cookstoves Technical Meeting: Summary Report, US Dept. of Energy, Office of Energy Efficiency and Renewable Energy, (May 2011) http://www1.eere.energy.gov/biomass/pdfs.cookstove_ meeting_summary.pdf.
35 http://www.nsf.gov/pubs/2011/nsf11022/nsf11022.jsp?org=NSF.
36 http://careers.state.gov/ff.
37 The 30th anniversary of the AAAS Fellows Program was recognized by the 108th Congress in House Congressional Resolution 279 and the concurrent Senate Congressional Resolution 107.
38 C. R. Robinson and A. I. Leshner, *2008—2009 AAAS Science and Technology Policy Fellowships Annual Review*; http://fellowships.aaas.org/PDFs/2008-09%20Annual%20Review.pdf.
39 http://www.aip.org/gov/fellowships/sdf.html.
40 http://www.ieeeusa.org/policy/GOVFEL/state.asp.
41 N. MacCarty, *et al.*, *Laboratory Comparisons of the Global-Warming Potential of Six Categories of Biomass Cooking Stoves*, Aprovecho Research Center, Creswell, OR 97426 (Sept. 2007); http://www.aprovecho.org/web-content/publications/assets/Global_warming_full_9-6-07.pdf.
42 J. Jetter and P. Kariher, "Solid-fuel household cook stoves: Characterization of performance and emissions," Biomass and Bioenergy **33**(2), 294–305 (2009).
43 The Philips stove includes a rechargeable battery that uses a "wall wart" as the charger so that in locations with intermittent electrical service, cooking is not interrupted. A fully-charged battery can operate the fan for 20 to 30 hours.
44 Biolite thermoelectric cook stoves: http://www.biolitestove.com/Technology.html.
45 C. Lertsatitthanakorn, "Electrical performance analysis and economic evaluation of combined biomass cook stove thermoelectric (BITE) generator," Bioresource Technology **98**, 1670–1674 (2007).
46 http://ww.damp.com or www.bancobmg.com.br.
47 http://www.aster-thermoacoustics.com/wp/wp-content/uploads/2010/11/TA-engine-with-alternator-_Proof-of-concept_-FINAL.pdf.
48 P. J. Montgomery and S. L. Garrett," Low-cost thermoacoustic co-generator for biomass-burning cook stoves," J. Acoust. Soc. Am. **128**(4), 2347 (2010).
49 W. L. M. M. Rijssenbeek, "Thermo Acoustic Generator," FACT Newsletter #8 (Jan.2011); http://factfoundation.m10.mailplus.nl/genericservice/code/servlet/React?encld=SSjAWEHx&actld-31069102&command=openhtml#2.
50 M. E. Poese, R. W. M. Smith, S. L. Garrett, R. van Gerwen, and P. Gosselin, Thermoacoustic refrigeration for ice cream sales," Int. Inst. Refrigeration 6th Gustav Lorentzen Natural Working Fluids Conference, Glasgow, UK, 1 Sept. 2004; US Pat Nos. 6,792,764 (Sept. 21, 2004), 7,055,332 (June 6, 2006), and 7,143,586 (Dec. 5, 2006).

Steve Garrett (right) and son, Adam

Steve Garrett received his Ph.D. in Physics at UCLA under the supervision of Seth Putterman and Isadore Rudnick. He was the first recipient of the Acoustical Society's F. V. Hunt Postdoctoral Fellowship in Acoustics and the Society's only winner of the Interdisciplinary Silver Medal in Physical and Engineering Acoustics. Dr. Garrett no longer wears a suit on a daily basis and enjoys working in the lab or spending time with his son and daughter.