

PHYSICS & SOCIETY

A Publication of The Forum on Physics and Society A Forum of The American Physical Society

Note from the Editor

With this issue I am taking over from Andrew Zwicker as Editor of P&S. I am very grateful to Andrew for showing me how things work: it is not an easy task and I have taxed his patience. The previous Editor (Cameron Reed) has also been very helpful. I also thank the Forum's Executive Committee for entrusting me with this responsibility. The standards set by my predecessors are truly daunting. I am very happy that Laura Berzak Hopkins has agreed to stay on as Assistant Editor, and Art Hobson as Reviews Editor, and that the entire Editorial Board is also continuing.

As many of you know, Andrew has left the job because of his election to the New Jersey legislature. I wish him the best in that capacity. He is a brave man. I can imagine many reasons why I would quit as Editor, but running for the Minnesota legislature will **never** be one of them.

P&S is largely dependent on contributions from its readership. Contributed articles (up to 2500 words), letters (500 words), commentary (1000 words), reviews (1000 words), and brief news items are requested. I will make exceptions to these length limits whenever reasonable. Send contributions to me, except for reviews, which should go to the reviews editor directly. Contributions are reviewed for style and appropriateness, but their content is **not peer reviewed**

and opinions given there are the author's, not mine, nor the Forum's. Therefore **I plan to be very open as to what is appropriate. Controversy is good.** Only articles consisting purely or largely of political opinions and advocacy, or tainted by *ad hominem* invective, or containing utterly unsound science of the "the world was created a few thousand years ago" variety will undergo summary editorial rejection.

Suggestions on possible topics and authors, and on how to improve and enhance this newsletter are also welcome.

I look forward to hearing from you.

Oriol



Oriol T. Valls, a Condensed Matter Theorist at the University of Minnesota, is the new P&S newsletter editor.

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Why Do Outreach?

James Kakalios

The March 1962 episode “Little Girl Lost” of the television anthology program *The Twilight Zone* added some speculative inter-dimensional physics to a suspenseful science fiction tale.[1] In this story a small child rolls out of her bed in the middle of the night and disappears. Her parents become frantic when they can hear her calls for help, but cannot see or touch her. Fortunately they know what to do in just such an emergency – they call for their neighbor Bill, who is a physicist. He determines that the girl has accidentally fallen through a portal into another dimension. With his aid, and the help of the family dog, they manage to retrieve their daughter. Whether this portal was to one of the extra dimensions predicted by String Theory is open to interpretation, but the show clearly demonstrated the utility of a friendly neighborhood physicist.

Indeed, in the early 1960’s, the U.S. Government had similarly concluded that it was worthwhile to have physicists and other scientists on call. Following the Manhattan Project; the development of radar; and the proximity fuse in World War II the value of scientists and engineers to national security was accepted by the general public. In 1942 West Virginia Senator Harley Kilgore had proposed legislation calling for federal support of scientific research and in 1945 Vannevar Bush’s report *Science, The Endless Frontier*, [2] forcefully argued that it was in the nation’s best interest to develop and maintain strength in what we now would refer to as STEM fields. In 1950 Congress responded with the establishment of the National Science Foundation.

The situation today is very different. There is no longer broad agreement among the public of the value of scientific research.[3] Which is ironic, for this same public has enthusiastically embraced personal electronics and technology that is enabled, in part, through federally funded research. As expressed a few years ago by a Dean at M.I.T., never before in human history have so many become so wealthy solely through education. [4].

It is clear that in the 21st century, physicists can no longer rely on the good will engendered during the middle of the 20th century. Rather than simply curse the darkness, some have taken to lighting candles, devoting time and effort to communicating the fruits of scientific research to the general public. I would argue that it is in the best interests of the physics community to support and encourage science outreach and engagement with the public, many of whom are voters and taxpayers.

Though sometimes conflated, outreach is not the same as education. Improving science education, particularly at the K-12 level, is of course vitally important. But as noted by Dr.

Neil deGrasse Tyson: “The problem is adults not knowing science. They outnumber kids 5 to one, they wield power, they write legislation.”[5] We’re familiar with the concept of an elevator pitch, where you find yourself on an elevator with a powerful person, such as a captain of industry, and have only eleven distraction-free seconds to make a proposal. Do you use your time to teach this individual some aspect of physics, or to try to convince them of the value of scientific research? There are many demands on the attention of the general public, and windows of opportunity for engagement are rare. Of course I would like everyone to know some physics and indeed most outreach involves relating some aspect of physics or a recent discovery to a general audience. But in communicating science, I would argue that an important goal is to instill a positive attitude toward science and scientific research. After all, everyone loves their smart phones, even though few know (or care) what goes on ‘under the hood.’

There already exist excellent channels for science communication, from *NOVA* on public broadcasting to popular science magazines on the newsstand to exhibits and events at science museums. These are all necessary, but not sufficient. Those who are reached via these means typically already have a positive attitude toward science. While it is important to preach to the choir, we must also find ways to grow the congregation. One method of outreach involves mining topics of entertainment, such as NASCAR, professional sports, Hollywood blockbusters, television sitcoms or superheroes, and using these subjects as springboards for discussions of science. Another method involves embedding the science directly into the source of recreation, an effort championed by the National Academy of Science’s Science & Entertainment Exchange [6] which connects academics with television and movie creators, with the goal of improving both the science content and representation of scientists in popular entertainment. Other approaches involve the creation of content that can then be broadly disseminated via the internet. But just as we are driven to innovate in our research, creative new methods for outreach are needed, particularly to reach underserved low-income and minority populations.[7]

While improvements in engagement with the public will, in my opinion, benefit all of us in physics, I am not arguing that everyone in physics should be active in outreach. Every member of a professional baseball team is a highly trained and skilled athlete, but rarely would a centerfielder do well if called upon to pitch, or even play shortstop. We all have our strengths and weaknesses, and just as not every physicist is best suited for research in String Theory or for working in a femtosecond laser spectroscopy lab (though sometimes it

does seem as if every physicist is working on graphene), not everyone need be involved in outreach.

Years ago my wife (who is not a physicist – it’s a mixed marriage) and I attended a general audience public talk by a distinguished physicist. I was able to follow his talk, though with effort. As we left the auditorium after the presentation, my wife commented: “Well, I learned one thing tonight. He belongs to a club that does not want me as a member.” It takes considerable effort and practice to communicate effectively to a non-scientifically trained audience. A few years ago I was fortunate to see first hand the training and devotion that a group of young physicists put into short presentations of their research for a general audience as part of a Physics Slam event associated with a Particle Physics conference held in Minneapolis. During this event the physicists would have ten minutes to convey their complex fields of study. In preparation they received guidance and instruction from professors in theater studies, and the attention to craft paid off in their presentations, rewarded by an enthusiastic response from the audience.

Often I will hear physicists lament the public’s lack of appreciation of the value of their research, typically followed by a related complaint concerning the dearth of research funding. As a community we should support (and not just tolerate) those who make an effort to do the hard work of engaging with the public, and at least not make their jobs harder.

After all, you never know the next time that someone’s daughter will fall through a breach in the spacetime continuum.

Editor’s note: Jim Kakalios’s efforts at outreach have been recognized by the American Institute of Physics’ 2016 Andrew Gemant Award for Significant Contributions to the Cultural, Artistic or Humanistic Dimension of Physics and the 2014 American Association for the Advancement of Science Award for Public Engagement with Science.

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- [7] Emily Dawson, “‘Not Designed for Us’: How Science Museums and Science Centers Socially Exclude Low-Income, Minority Ethnic Groups,” *Science Education* 98 981 (2014).

Physics and Society is the non-peer-reviewed quarterly newsletter of the Forum on Physics and Society, a division of the American Physical Society. It presents letters, commentary, book reviews and articles on the relations of physics and the physics community to government and society. It also carries news of the Forum and provides a medium for Forum members to exchange ideas. **Opinions expressed are those of the authors alone and do not necessarily reflect the views of the APS or of the Forum. Articles are not peer reviewed.** Contributed articles (up to 2500 words), letters (500 words), commentary (1000 words), reviews (1000 words) and brief news articles are welcome. Send them to the relevant editor by e-mail (preferred) or regular mail.

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Physics of Sustainable Energy: a Short Course

Pushpa Bhat and Rob Knapp

The Forum on Physics & Society (FPS) has been organizing 2-3 day short courses, periodically, on topics such as energy, global warming, nuclear weapons, arms race, etc. Three successful short-courses on “Physics of Sustainable Energy: Producing Energy Renewably and Using it Efficiently” have been held in the years 2008, 2011 and 2014, all at the University of California, Berkeley. There was a strong desire and support in the FPS executive committee to continue to organize this series, and to move it around the country to provide access to a broader audience. This year, we had the pleasure of organizing (along with Bob Rosner and George Crabtree) the fourth in the series, “Physics of Sustainable Energy –IV (PSE-IV)”, at the University of Chicago, during June 17-18, 2016. The short-course/conference was sponsored by the FPS, and co-sponsored by Fermi Research Alliance (FRA), Argonne National Laboratory (ANL) and the Energy Policy Institute at the University of Chicago (EPIC).

The PSE-IV short-course was broadly formatted along the lines of its successful predecessors. It was aimed at researchers, faculty and students, and private and public sector professionals active in energy affairs. The primary goal was to provide an intense overview and facilitate discussion of the opportunities and obstacles facing sustainable production and use of energy in the United States. Eight sessions, over two full days, covered (1) Energy Landscape and Challenges, (2) Renewable Energy Technologies, (3) Nuclear Energy, (4) Energy efficiency, Sustainability, and Energy Security, (5) “Classical” Energy Storage Solutions, (6) Innovations in Energy Storage, (7) Energy Infrastructure and Distribution, and (8) Energy Policy. The scope of the participation was broadened, relative to the previous meetings, to include economists and energy policy experts, along with physicists, engineers, chemists, material scientists and technologists. This interdisciplinary approach made the conference very exciting and was praised as very beneficial by all those who participated.

Opening the conference, Peter Littlewood remarked that energy is money and that the electrical storage needs a revolution. Bob Rosner gave an overview of our energy challenges. Through the various sessions, attention to questions of implementation and policy was prominently noticeable at this meeting, reflecting the increasing maturity of the nationally significant supply technologies and a renewed awareness of the sheer scale of the system shifts required to make meaningful progress on carbon emissions. Almost all speakers emphasized electric power as the point-of-use form of supply, even for transportation. An interesting exception was Said Al-Hallej’s presentation

on thermal storage in commercial buildings. Photovoltaics (Greg Wilson) and nuclear power generation (Tanju Sofu, Charles Ferguson) both received solid discussion, outlining both the respective histories and the distinct challenges each must overcome over the next 5-10 years. There was repeated attention to questions of storage, both in technical terms (George Crabtree on batteries, Di-Jia Liu on hydrogen for vehicles) and in relation to the structure and management of the power grid (Leah Guzowski, Steve Cicala).

There was also sober discussion of the relation between projected and achieved reduction in energy use and carbon emission. A specific study of household weatherization (reported by Michael Greenstone) found results far short of expectation, highlighting the difficulties of scaling up energy efficiency. Additional cautions were sounded about whether reduced US fossil fuel use might not encourage increased use elsewhere, about the reliability of simulations for comparing policy alternatives, and about the needs for energy security as well as carbon reductions, among other issues.

There were a total of about 75 participants, including several undergraduate students from across the country. National labs, universities and the private sector were all represented and mutually engaged. Discussion from the floor was lively throughout, during the sessions and breaks. The conference banquet on June 17th featured a keynote speech by Congressman Bill Foster (IL-11).

This short summary cannot do justice to the range and substance of the two days of presentations and discussions. The detailed agenda and presentation slides of the talks are available at the following web site: <https://epic.uchicago.edu/short-course-physics-sustainable-energy-program>

The American Institute of Physics will publish the conference proceedings. The attendees get a one-year free access to the online proceedings, and the printed proceedings are expected to be available by the end of the calendar year 2016.

The success of PSE-IV has left its local organizers with great enthusiasm and eagerness to propose hosting once again the next round, PSE-V, at EPIC at the University of Chicago, in 2018.

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Fusion Reactors Share Seven Drawbacks of Fission Reactors

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The proponents of fusion reactors claim that, when developed, such reactors will constitute the “perfect” energy source, and in particular will share none of the significant drawbacks of much-maligned fission reactors. That claim is contrary to fact. If fusion reactors are feasible, they would share seven serious disadvantages of fission reactors stemming from neutron production, tritium usage, coolant demands and operating costs. These issues are endemic to *any type* of MCF (magnetic confinement) or ICF (inertial confinement) fusion reactor that’s fueled with D-T (deuterium-tritium) or deuterium alone. The first five of the drawbacks discussed below have been considered individually for decades, but apparently never before compiled. The sixth and seventh, although critical, have been ignored.

1. **Radiation damage** to the structure imperils reactor integrity. In reactors fueled with D-T, eighty percent of the fusion energy consists of streams of 14-MeV neutrons. To produce usable heat, these neutron streams must be decelerated and thermalized by the reactor structure. The majority of reactor concepts use a solid first-wall and blanket structure, where the neutron radiation damage is expected to be worse than in fission reactors because of the higher neutron energies [1, 2]. Fusion neutrons knock atoms out of their usual lattice positions, causing swelling and fracturing of the structure. Also, large amounts of interstitial helium and hydrogen are generated, forming gas pockets that lead to additional swelling, embrittlement and fatigue.

In reactors with D-only fueling (much more difficult to ignite), the neutron reaction product has a lower energy (2.5 MeV) and the neutron streams are substantially less damaging on structures. However, a significant fraction of the tritium reaction product will unavoidably be burned to produce 14-MeV neutrons, and the deleterious effects on structures will still be ruinous on a longer time scale. If a practical source of He-3 can be found, neutron damage and activation can be reduced by an order of magnitude if the reactor utilizes the 3He-D fuel cycle, where D-D reactions will comprise less than 1/4 of the total reaction rate. The problem of neutron-degraded structures may be alleviated in those ICF and hybrid ICF/MCF concepts where the fusion fuel capsule is enclosed in a thick liquid lithium sphere or cylinder. But the fuel assemblies themselves will be transformed into tons of radioactive waste to be removed annually from each reactor. Molten lithium also presents a fire and explosion hazard, introducing a drawback common to liquid-metal cooled fission reactors.

2. **Radioactive Waste.** As noted above, bombardment by fusion neutrons knocks atoms out of their structural positions while making them radioactive and weakening the structure, which must be replaced periodically. That results in huge masses of highly radioactive materials that must eventually be transported offsite for burial. Many non-structural components inside the reaction vessel and in the blanket will also become highly radioactive by neutron activation. While the radioactivity level per kilogram of waste will be much smaller than for fission-reactor wastes, *the volume and mass of wastes will be many times larger* [3].

Fusioners speculate that a low-activation structural alloy can be developed that will allow discarded reactor materials to qualify as low-level radioactive waste and disposed of by shallow land burial [4]. Even if feasible, no municipality or county is likely to accept such a landfill.

3. Extensive **radiation shielding** is needed to reduce radiation exposure of plant workers, even when the reactor is not operating. In the intensely radioactive environment, remote handling equipment and robots will be required for all maintenance work on reactor components as well as for their replacement because of radiation damage, particle erosion or melting. Remote handling equipment must also be used for the disposal of radioactive waste.

4. **Tritium Release.** Corrosion in the heat exchange system or a breach in the reactor vacuum ducts could result in the release of radioactive tritium into the atmosphere or local water resources. Tritium will be dispersed on the surfaces of the reaction vessel, particle injectors, pumping ducts and other appendages. Preventing tritium permeation through solids remains a critical unsolved problem, so that some of this embedded tritium will eventually find its way into external cooling systems. Most fission reactors contain trivial amounts of tritium (< 1 gram) compared with putative fusion reactors (kilograms), but the release of even tiny amounts of tritium into the cooling water of fission reactors causes public consternation [5].

5. **Nuclear Proliferation.** The open or clandestine **production of Pu-239** is possible in a fusion reactor simply by placing natural or depleted uranium at any location where neutrons of any energy are flying about, including appendages to the reaction vessel. With D-only fueling, tritium breeding is not required and *all* the neutrons will be available for Pu-239 production. The reactor mission could be dedicated to that purpose.

A reactor fueled with D-T or D-only will have an inventory of at least kilograms of tritium, and possibly tens of kilograms. This inventory will reside in the blanket, in tritium processing systems, and embedded in reactor components, providing opportunities for **diversion of tritium** for use in nuclear weapons [6].

Just as for fission reactors, IAEA safeguards will be needed to prevent plutonium production or tritium diversion.

6. Coolant Demands. A fusion reactor is a thermal power plant like one based on coal burning or nuclear fission, and would place immense demands on **water resources** for the secondary cooling loop that generates steam as well as for removing heat from other reactor subsystems such as cryogenic refrigerators and pumping. A fusion reactor would require at least 30,000 gallons per megawatt-hour of “once-through” cooling, and must compete with agriculture and industry for often diminishing water resources. With drought conditions intensifying in many regions of the world, many countries could not support any fusion reactor, even with cooling towers to mitigate water demand.

7. Outsized Operating Expenses. Fission reactors are presently being shut down in the U.S. because the *operational costs alone* result in an uncompetitive cost of electricity [7]. (The capital outlays have long been paid down or written down.) Fission plants typically require at least 500 workers over four weekly shifts. Fusion reactors will also need personnel heretofore peculiar to fission plants such as security experts for monitoring safeguard issues and specialty workers to dispose of radioactive waste. Additional skilled personnel will be required to operate a fusion reactor’s more complex subsystems including cryogenics, plasma heating equipment and elaborate diagnostics. Another intractable operating expense is the large amount of electrical power consumed by fusion reactor subsystems, associated facilities and buildings during inevitable downtimes. For example, the ITER facility will consume 110 MWe even when the tokamak plasma is not operating [8]. There are also multiple recurring expenses including replacement of radiation-damaged components in MCF and fabrication of millions of fuel capsules for each ICF reactor. A corollary of extraordinarily high and

irreducible operating costs is that the capital cost of a fusion reactor must be close to zero for economic competitiveness!

These seven drawbacks shared with fission reactors apply to any fusion energy concept. While radiation damage and waste production may be mitigated if the fusion source can be surrounded by thick lithium-metal blankets, or fueled with ^3He -D, the other detriments are irremediable. Fusion proponents constantly call for a “crash program” to develop a commercial reactor. (Presumably a crash program is one that’s shorter than the half-century ITER odyssey.) But even if a working fusion reactor could be demonstrated, these drawbacks would make deployment impossible wherever fission reactors face widespread public opposition or wherever their operating costs alone produce a non-competitive cost of electricity.

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Candidates for Office in the Forum on Physics and Society

CANDIDATES FOR VICE CHAIR:

WILLIAM BARLETTA AND JOEL PRIMACK

William Barletta

Biography: William Barletta is Director of the US Particle Accelerator School, Fermilab and Adjunct Professor of Physics at MIT, UCLA and Old Dominion, Director Emeritus of the Accelerator Division and Homeland Security Program at LBNL. He served on DOE's Basic Energy Sciences Advisory Committee contributing to studies of Science for Sustainable Energy and on Mesoscale Science. He co-chaired BES studies of Accelerators for Future Light Sources, Opportunities for Compact Light Sources, and the BES facility prioritization sub-panel. He chaired Visiting Committees for the BES Division of Scientific User Facilities (2013) and for Research Engineering at LANL (2012–). He is Coordinating Editor-in-Chief of NIM –A, senior advisor to the President of Sincrotrone Trieste and Visiting Professor, Faculty of Economics, University of Ljubljana. He co-chairs the Permanent Monitoring Panel on Energy of the World Federation of Scientists and is a member of its Panel on Information Security. He was founding director of the Korean Accelerator School and is co-convenor of the USPAS, CERN, KEK and Budker Joint Accelerator School

He was Chair of the APS Forum on International Physics and the Division of Physics of Beams. He was Convenor for Accelerator Capabilities for the DPF “Snowmass 2013” study. He was an active member of the APS Committee on Minorities (2004–2006), APS Panel on Public Affairs (2009–2011 and 2013–2016) and is now POPA past chair. He has served on the APS Committee on International Scientific Affairs (2011 – 2015), the APS Physics Policy Committee (2015) and the ABA Privacy & Computer Crime Committee (2006 – 2012). He recently served on the POPA study on license extension of reactors. His present research includes neutrino sources, high intensity cyclotrons, high luminosity proton colliders, ultra-short pulse X-ray sources, free electron laser physics, applications of ion beams to nanotechnology, and international legal aspects of cyber-security.

He has organized international schools in accelerator technologies and was founding director of the International School of Innovative Technology for Cleaning the Environment. He edited four books about accelerator science, co-authored four books concerning cybersecurity, privacy and international cyber-law, including, “Averting Disaster: Science for Peace in a Perilous Age” and “The Quest for Cyber Peace,” pub-

lished by the International Telecommunications Union. He holds four patents and published 180 scientific papers plus 30 reports on strategic technologies. He holds a Ph.D. (Physics) from the University of Chicago and is a fellow of the APS and a member of the European Physical Society.

Statement: FPS has the crucial mission in the APS of exploring and articulating the many ways in which the physical sciences influence society in the broadest sense. The FPS sessions at APS meetings and the FPS newsletter provide a platform for even-handed, grassroots debate on issues of great concern and impact on physicists and on society as a whole. FPS activities also provide a highly visible means for APS members to educate themselves on issues of national and international importance. This vital program must continue and ideally expand.

FPS looks inward at the APS to identify how public issues affect the community of physicists. It looks outward to articulate how the insights of physics influence the public debate on issues as diverse and as charged as downsizing the nuclear arsenal, energy policy, the future of nuclear power, proliferation of nuclear weapons, and ballistic missile defense, just to name a few. For this reason FPS has a standing representative on the APS Panel on Public Affairs giving it an important voice formulating APS statements and in conducting studies for the APS.

During the next several years the U.S. government must continue its investments in energy efficiency and low carbon emission technologies. Controlling nuclear proliferation and counterterrorism while balancing the privacy concerns and human rights will remain vital public issues with deep technological roots. Every policy choice has both risks and benefits. Being independent of commercial and partisan interests, the APS is the vehicle by which American physicists can and should inform the public debate with the same intellectual discipline, rigor, and open-minded skepticism that we value in our physics research. That goal of broader public education has frequently begun with the FPS process of inquiry and debate.

At this stage of my career, I am deeply committed to the education both of the public and of those seeking or engaged in careers in the physical sciences and engineering. Given my extensive activities within the APS and my broad experience ranging from strategic studies and energy technologies to accelerator physics and technology for scientific research facilities, I am enthusiastic to participate as a member of the chair line in the FPS mission of influencing the connections between physics and the broader society.

Joel R. Primack

Biography: I am now Distinguished Professor of Physics Emeritus, University of California Santa Cruz. My early research helped create the Standard Model of particle physics, but since the late 1970s I have worked mainly on the physics of the universe. I am a main author and developer of Cold Dark Matter, the basis of the modern theory of structure formation in the universe from the cosmic background radiation to galaxies. I was made a fellow of the American Physical Society (APS) in 1988 “for pioneering contributions to gauge theory and cosmology.” I am an author of more than 200 refereed articles; my h-index is 70. I am coauthor of the book *Advice and Dissent: Scientists in the Political Arena* (1974); two books on modern cosmology and its implications: *The View from the Center of the Universe: Discovering Our Extraordinary Place in the Cosmos* (2006), and *The New Universe and the Human Future: How a Shared Cosmology Could Transform the World* (2011); and also many articles in magazines.

In 1995 I was made a fellow of the American Association for the Advancement of Science (AAAS) “for pioneering efforts in the establishment of the AAAS Congressional Science Fellows Program [the beginning of the AAAS fellowships that now help to place 250 scientists and engineers in the executive, legislative, and judicial branches annually] and for dedication to expanding the use of science in policymaking throughout government.” In 1973 I helped to create the APS Forum on Physics and Society. In 1973-74 I led the effort to organize the first APS studies on public policy issues. I worked with Senator Ted Kennedy in 1976-78 to create the NSF Science for Citizens Program. I initiated the AAAS Science and Human Rights program, which has rescued many scientists and non-scientists. In 1987-89 I led the Federation of American Scientists Space Nuclear Power Arms Control project, which helped to end the USSR’s orbiting nuclear reactor program. As a member of the APS Panel on Public Affairs (POPA), I led the APS study on the destructive effects on science of President George W. Bush’s 2004 Vision for Space Exploration. I served as FPS chair in 2005-06. I was chair of the AAAS committee on Science, Ethics, and Religion 2000-2002, and of the APS Sakharov Prize committee 2009. In 2016 I received the APS Leo Szilard Lectureship Award for outstanding accomplishments in promoting the use of physics for the benefit of society.

Statement: As people everywhere grapple with increasingly challenging global issues, science is both essential to guide us toward optimal solutions, and increasingly under attack. My highest priority as chairman of the Forum on Physics and Society would be to promote better understanding of science by the general public and better decisions regarding science and technology policy. One important way FPS can do this would be to create programs to improve physicists’ communication skills, including through social media. Excellent science reporting can help, but physicists themselves

– particularly diverse and articulate ones – are needed to explain science to the public. The APS could encourage this by recognizing exemplary efforts by physicists at all stages of their careers with annual awards. FPS can also develop new ways for physicists to interact with government at all levels, including local and state, such as the California Science & Technology Policy Fellows program. It is important that the public understand better the different levels of scientific certainty in different areas, so that they do not mistrust conclusions that are supported by strong evidence, such as human-caused global climate change, because of frequently changing advice in uncertain areas like dietary guidelines – or because of efforts by a small number of scientists to raise unwarranted doubt on issues like cigarette smoking, sugar, acid rain, ozone, and climate. (Please see also my July 2016 APS News Back Page piece based on my Leo Szilard Award lecture “How Can Physicists Help the Public Make Better Decisions About Science and Technology?” <https://www.aps.org/publications/apsnews/201607/backpage.cfm> and my article in the July 2016 issue of Physics and Society <https://www.aps.org/units/fps/newsletters/201607/primack.cfm>.)

CANDIDATES FOR POSITION 1 ON THE EXECUTIVE COMMITTEE:

KELLY CHIPPS AND CHRIS SPITZER

Kelly Chipps

Biography: After a semester in astronomy, Kelly Chipps completed a PhD in experimental nuclear astrophysics from the Colorado School of Mines in Golden, Colorado. During this time, she served on the Graduate Student Association, helping to create a new child-care grant for fellow students. Work as a postdoc for Rutgers University, the University of York in the UK, and the Colorado School of Mines, was followed by a research staff position at the University of Tennessee Knoxville. Her focus as a scientist has been on studying, in the laboratory, the nuclear reactions that power stars and stellar explosions. Currently, she continues this line of research as a Liane B. Russell Fellow at Oak Ridge National Laboratory. As a nuclear physicist, she has a keen interest in the public perception of nuclear energy and the history of the national laboratories. She participates in outreach programs with ORNL, the American Museum of Science and Energy, and on social media, to encourage public participation and interest in science.

Statement: Society currently has a love-hate relationship with science. Everywhere we look, people deny convenient pieces of science while benefiting from other portions; climate change and evolution are disbelieved while quantum mechanics and general relativity quietly provide the satellites and cell phones those same individuals use every day. Import-

tantly, the general public opinion can negatively impact policy decisions on science. I believe it is important to emphasize scientific literacy, not only to fill the STEM “leaky pipeline” and produce more good scientists, but also to provide the general public the means to gain a better understanding of the basis behind the science and tech all around them. With the right knowledge, people can filter out the noise around science and technology and help lead the country toward making more informed policy decisions. This is where I feel that the Forum on Physics & Society can play an important role - by proactively engaging our fellow scientists to engage the public, in particular by encouraging (and supporting, where possible) science cafes, social media programs, public lectures and debates, open houses, and involvement with local schools. Science should be a language that is accessible to everyone, and the more people have a basic fluency in it, the more public policy will reflect that understanding.

Chris Spitzer

Biography: Chris Spitzer is an early-career physicist with significant experience in science policy and the creation of programs that expand the field’s reach. He currently serves as Program Officer in UC Research Initiatives, a grant-making office of the University of California. As the lead on the Lab Fees Research Program, he has enhanced the University’s inclusion of graduate students, mentorship of young faculty and scientists, and engagement with the social sciences in multi-institution research collaborations. He was the lead Program Officer on the UC President’s Research Catalyst Awards and covers the physical sciences and engineering in the UC Multi-campus Research Programs and Initiatives.

Dr. Spitzer spent a number of years as a policy practitioner in DC, starting as the American Institute of Physics Congressional Fellow in the office of Senator Jeanne Shaheen in 2010-2011. His portfolio included budgetary oversight of the Department of Energy, energy efficiency legislation, responses to the Fukushima accident, and promotion of research in the wake of the Deepwater Horizon oil spill. From 2011-2013, he was a AAAS Science and Technology Policy Fellow at the State Department. Primarily focused on Afghanistan, he worked to incorporate science and data-driven approaches into State’s actions on economic development, energy, water security, and environmental protection. The Department recognized this work with two Superior Honor Awards. Dr. Spitzer remained at State through 2014 in the Energy Bureau, where he developed programs that improve the efficient use of energy in south Asia and north Africa.

He has also held a AAAS Mass Media Fellowship, sponsored by APS, and continues to be engaged in science communication. In addition to describing the benefits of UC’s research programs to the public, he writes for AAAS MemberCentral, covering federal science policy and a recurring

feature that highlights AAAS members who are teachers.

Dr. Spitzer holds a Ph.D. in particle theory from the University of Washington (2009), where he was an officer in the Forum on Science, Ethics, and Policy. He holds a B.A. in Physics and a B.S. in Computer Science, and Electrical Engineering from Berkeley (2001). He was a postdoc at Washington University in St. Louis, and was previously in George Smoot’s group at Lawrence Berkeley Lab.

Statement: As a physicist who has worked in the U.S. Senate and the State Department, I’ve seen first-hand the importance of effective communication of science with policy makers and the public. FPS plays a crucial role in fostering discussion of societally important issues within in the physics community, and in preparing physicists to effectively engage outside of the field.

As Member-at-Large, in addition to supporting existing activities, I would vigorously work to expand FPS’s reach. Specifically, I am interested in increasing the number of members who are knowledgeable in issues at the intersection of science, technology, and policy, and who have the skills needed to interact productively with the public. I believe an important component of this effort would be additional outreach to graduate students and early-career faculty and researchers, who will become the backbone of FPS’s mission in the years to come.

Outreach, including educational events and training opportunities, could focus on either key societal issues such as energy, the environment, and emerging technological challenges like privacy, or on the importance of basic research to society. As a theorist, the latter topic is one which I’ve often found is overlooked in policy discussions but is vital to positioning ourselves to address future challenges.

My background has positioned me well to conceptualize and execute these types of activities, and if elected as Member-at-Large I look forward to working hard to advance FPS’s goals. Thank you for your consideration.

CANDIDATES FOR POSITION 2 ON THE EXECUTIVE COMMITTEE:

WARREN BUCK AND LISBETH GRONLUND

Warren W. Buck

Biography: PhD in theoretical intermediate energy physics from William and Mary with Franz Gross, Post doc at Stony Brook with Gerry Brown, Research Associate at the University of Paris ORSAY lab with Robert Vinh Mau, extensive three year sailing and watercolor painting voyage ending in 1983. Buck joined the faculty of Hampton University in 1984 and did all the ground work to establish a Hall C

experimental program at the Jefferson Lab prior to making any hires at Hampton. He created and was founding

Director of the NSF funded NuHEP Research Center of Excellence that was the mechanism through which Hall C detector equipment was built or refurbished for the Jefferson Lab; and this NSF funded Center was critical in establishing a new PhD degree offering in Physics at Hampton University. When the national average of African American PhD's graduated was 0.5 per year, we Hampton was graduating 2-4 PhD's per year. The experimentalists Buck recruited and hired through the NuHEP Center not only became the first to have approved experiments at a national lab from an HBCU; but also, there were many experiments. Today former members from the NuHEP Center have university professorships, industry leadership, and prominent leadership positions at the Jefferson Lab as well as having a continual set of experiments approved. Buck also created and was founding Director the HUGS at CEBAF (at JLab) summer school now moving into its 32nd consecutive year. Buck served as the Chair of the APS Committee on Education during the time that helped to establish and launch the Forum on Education. His theoretical work on the deuteron was part of the justification for the theory proposal of CEBAF; and additional theoretical work was motivation for experiments to measure elastic and semi-leptonic meson form factors. In 1999, Buck was recruited away from Hampton and JLab to be the first Chancellor of the University of Washington's newest campus in Bothell (UWB). Buck oversaw the major portion of completing the new UWB campus buildings and moving from the old campus to the new one. In moving to the new campus UWB was and still is co-located with the state's newest community college and co-locating agreements were established under his watch. His administration additionally took an upper division campus only to a full four year campus. After stepping down as Chancellor, Buck built and was founding Director of the UWB Science and Technology Program that has now transitioned to the School of STEM under the leadership of a dean (a new hire) and the nation's newest Physics undergraduate degree offerings with SPS student membership. Among other things, Buck has been Visiting Professor of Physics at several universities in the United States and Europe. He was co-chair of the 2008 NRC study on Opening New Frontiers in Space: Choices for the Next New Frontiers Announcement of Opportunity. Buck serves on the NSF's Advisory Committee for Business and Operations. Buck retired from the University of Washington June 2016 as professor emeritus and chancellor emeritus and now serves on the Board of Visitors of the College of William and Mary as well as on the Board of Trustees of the Pacific Northwest University of Health Sciences. He is a Fellow of the APS and a life member. He and his wife, Cate, have four adult children and two grand children.

Statement: My leadership in physics, leadership at the most senior levels of university administration, and my well roundedness with ability to converse with most anyone will

help the Executive Committee make decisions that will help the Forum agenda move forward.

Lisbeth Gronlund

Biography: Lisbeth Gronlund is a Senior Scientist and Co-director of the Global Security Program at the Union of Concerned Scientists. She has worked professionally on issues of international security for almost 30 years. Before joining the staff of the Union of Concerned Scientists in 1992, she was an SSRC-MacArthur Foundation fellow in international peace and security at the University of Maryland and a post-doctoral fellow at the Massachusetts Institute of Technology Defense and Arms Control Studies Program.

She holds a Ph.D. in theoretical physics from Cornell University. She is a fellow of the APS and of the American Association for the Advancement of Science.

Gronlund served on the Executive Committee of the Forum on Physics and Society from 1992 to 1995, and was a member of the APS Panel on Public Affairs (POPA) from 2000 to 2003.

Her research has focused on technical and policy issues related to nuclear weapons, ballistic missile defenses, and space security. She has authored numerous articles and reports, given talks about nuclear arms control and missile defense policy issues to both lay and expert audiences, and testified before Congress. She is frequently cited in the media and regularly meets with administration officials and members of Congress or their staff to provide information and advocate for policy change.

Since 1990, Dr. Gronlund has been a primary organizer of the International Summer Symposia on Science and World Affairs, which help train a new generation of scientists from around the world to work on arms control and security issues, and to foster an international community of such scientists. In recognition of this work, she is the co-recipient of the 2001 Joseph A. Burton Forum Award "for creative and sustained leadership in building an international arms-control-physics community and for her excellence in arms control physics."

Statement: The Forum on Physics and Society performs a valuable function within the professional community of physicists—it provides opportunities for APS members to educate themselves on important societal issues, and to do so easily.

I served on the FPS Executive Committee over 20 years ago, and am eager to again become engaged with the Forum.

I have some ideas about how to increase the reach and impact of the FPS that I will explore if I am elected to the Executive Committee.

First, to complement its sessions at APS meetings, FPS could sponsor a regular series of hour-long webinars on topics of interest to Forum members. There is very low overhead

for such webinars—my organization runs them frequently. Webinars would both allow Forum members who do not travel to APS meetings to take part in Forum activities, and facilitate getting speakers who do not have the time to travel to APS meetings.

Second, the Resources section of the FPS website could be updated and expanded to make it more useful to physicists who are interested in these issues but are not experts. For example, the list of journals could be expanded and annotated, as could the science and policy links.

Third, to complement its quarterly newsletter, the Forum

could email its membership on a more frequent basis with information about relevant news, articles and reports. The FPS would need to commission physicists working in various fields to identify relevant material.

Finally, there may be ways in which the FPS could do a better job of advertising itself to APS members. For example, the landing page of the FPS website could be rewritten to be more engaging. More generally, I would like to understand what the FPS currently does to advertise itself and its APS meeting sessions, and how those efforts could be augmented.

Forum Fellowship Nominations

Richard Wiener, Barbara A. Jones, Allen Lee Sessoms, and Beverly Hartline

Each year the APS elects a select group of members to Fellowship, a distinct honor signifying high recognition by one's professional peers. Only 1/2% of the entire APS membership may receive this honor in any given year. The criterion for election is exceptional contributions to the physics enterprise; e.g., outstanding physics research, important applications of physics, leadership in or service to physics, or significant contributions to physics education.

As part of the election process, each unit of the APS has a number of fellowship slots available for nomination annually. Over the past several years, FPS has fallen far short of its allotment.

The FPS Fellowship Committee wishes to strongly encourage fellowship nominations of truly deserving FPS members, especially women and members of underrepresented minorities. It is essential that nominations for fellows that come through FPS must emphasize contributions at the interface of physics and society, not just contributions to physics or to society or to institutions.

The FPS Fellowship Committee does receive a number of excellent nominations for fellowships each year. The committee is always impressed by the thoroughness and thoughtfulness of those who take the time to make these suggestions. Unfortunately, the committee has been less impressed by the quality of the letters of support for some of those nominations.

In a number of instances, support letters seem to lack enthusiasm, and in some cases, they lack personal knowledge of those they are intended to support. Further, they sometimes lack insight into why the person nominated

merits elevation to the status of fellow through FPS. The number of nominations that FPS can put forward is therefore extremely limited. It is incumbent on those who agree to write a letter of support to take the time, and to provide the personal insights, necessary to make the strongest possible case.

A significant, and surprising, problem has been that some people who agree to write support letters either don't do them or don't submit them on time, leaving the nominations incomplete or too late to forward to the APS Council. When the Fellowship committee does not receive promised support letters, it undermines the integrity of the nomination process.

Once the FPS nominating committee puts forward the nominations they must pass muster with the APS Council, which ultimately makes the award on behalf of the entire society. In the recent past, the committee has chosen not to forward nominations to the Council because even though the candidate was meritorious and had an outstanding recommendation from the nominator, the package of support letters did not pass muster.

After this year's nomination process, the committee decided to communicate the following message to members of FPS, "We urge everyone who agrees to write a support letter to write it in the spirit of those who make the initial nominations. We feel it necessary to emphasize that whenever you accept the responsibility of providing a letter in support of a fellowship nomination, you spend the time and energy to do one that does the nominee and her contributions at the interface of physics and society full justice."

Report on Survey of Members of the FPS

Ruth Howes, Chair, FPS and Bev Hartline, Vice Chair, FPS

Six hundred and eleven members of the Forum on Physics and Society responded to the survey over the summer to let us know their priorities for FPS engagement and action. The purpose of the survey was to determine with what issues members thought FPS should be involved; what methods the forum should use to approach these issues; and how individual members would like to be involved. By asking what members think, we hope to establish an agenda for the Forum that will both interest members and advance the interests of physics and the physics community in the future.

WHAT DID FORUM MEMBERS SAY?

Energy and the environment, climate change, and nuclear weapons and arms control were the three topics of interest to the most members. Among “other” issues that respondents identified, beyond the choices in the question, surprisingly, the two most often mentioned areas were educating the public about physics and increasing the diversity of physicists. Other issues cited were education at all levels of schooling including college, jobs, funding for physics, and population control, as well as de-politicization and internationalization of physics, climate and energy issues, media and cyber security, the role of physics in managing technological change and the relationship of physics to humanities, social sciences and religion.

The second question on the survey asked what actions FPS should take on these issues. The top two choices, in a near tie—both supported by about two-thirds of respondents—were to organize sessions at APS meetings and to conduct issue-specific studies. Among the “other actions” recommended, the most frequently cited activity was interacting to inform elected officials, which is currently the job of the APS Office of Public Affairs. Perhaps the message for FPS is to work more closely with other entities of APS. Several members suggested that Forum could make better use of media—especially to inform members, host discussions, or reach out to the public. The FPS Newsletter received strong support and a suggestion that it should feature occasional topical theme issues. These ideas will be discussed by the executive committee and at the upcoming 2017 business meeting (PLEASE COME), and they can lead to some concrete projects involving a larger cross section of members. As these initiatives take shape, we invite members to participate and even lead those where they are passionate.

CONCLUSION

The final question on the survey asked for additional thoughts on how the Forum can engage more members and have a greater impact. Responses were varied widely and were certainly one of the most useful parts of the survey responses.

Members warned against liberal bias and concentrating solely on nuclear issues. They asked for more opportunities for early-career physicists, and some advocated scholarships or career fairs. Many respondents suggested more effective use of social media and the main-line media to foster discussion and disseminate information from sessions and discussions to physicists and the public. Several members suggested collaborations with a wide variety of APS units and committees, including POPA, FIP, FED, the Government Affairs Office, and other APS departments, and with organizations similar to FPS within other scientific professional societies, such as the ACS and UCS. We especially want to shout out our favorite suggestion: “Speak Louder.”

In summary, the survey confirms the commitment of many FPS members to put their energies to work bringing creative ideas to live that benefit physics and society and the interface between the two. More than 100 people provided contact information and expressed an interest in getting personally involved. They will hear from us individually. We on the Executive Committee thank all respondents for sharing their ideas, and we pledge to follow up with near-term actions we can take to engage the members and put at least some of these ideas into practice. The first action is this article in the FPS Newsletter! Watch for more.

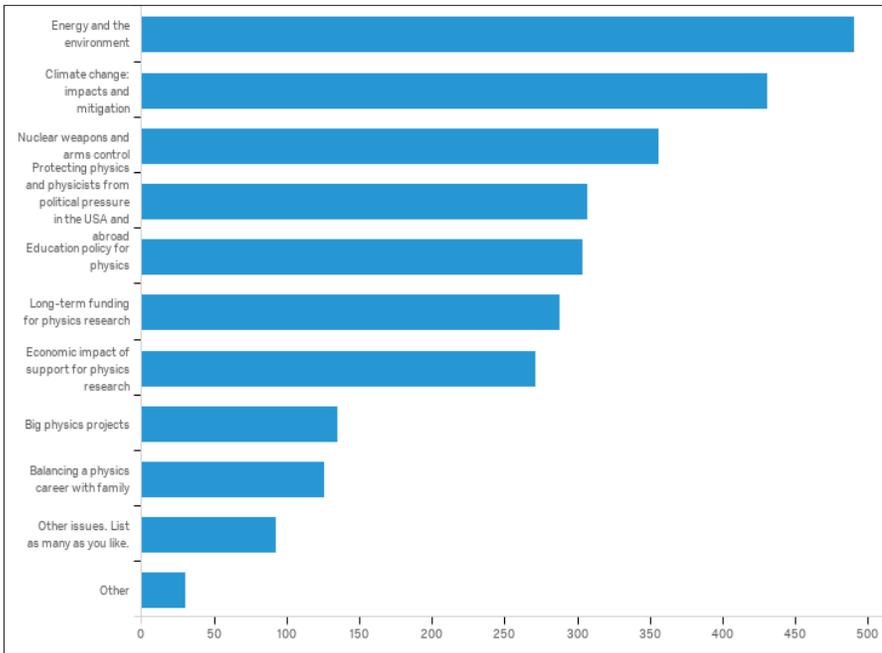
ABOUT THE RESPONDENTS

About 10% of FPS members took the time during summer to complete the survey. Not everyone answered all questions or provided demographic information. The participants included at least 44 foreign members; at least 110 members from the eastern U.S. at least 77 Westerners, at least 62 Midwesterners, and 11 members whose response defied simple geographic classification—clearly a broad geographic spectrum of members. Survey participants also represented a range of membership tenure—including those quite new to the forum (~10%). We were pleased that so many loyal, long-standing, and committed forum members responded.

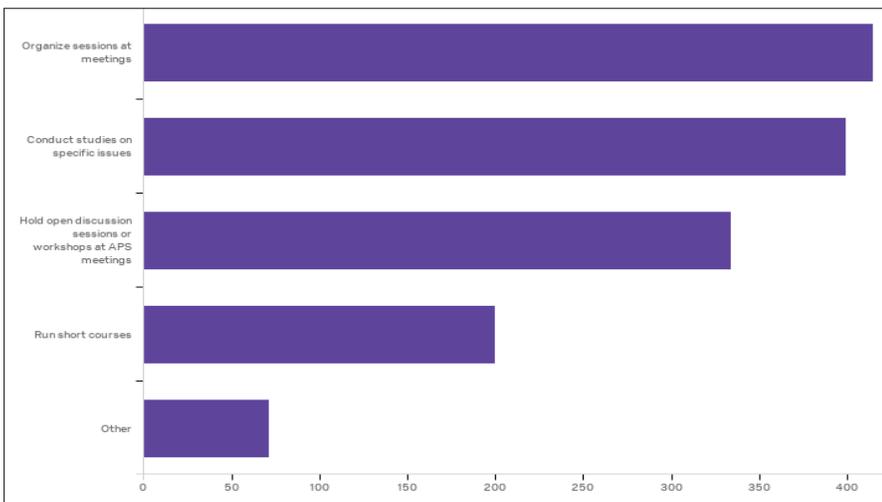
The distribution of respondents by employment sector is shown below with a large number of responses from retirees. As with many questions on the survey, quite interesting responses came from the short answers: 2 students, 3 grad students, 2 tutors, 4 consultants, a writer, a business person, someone who works both as a teacher and for a non-profit, 2 people who are self-employed, and a job seeker. Clearly FPS members are in a broad range of non-traditional career paths, as well as traditional ones.

We look forward to working with you to pursue many of these ideas, and we look forward to your involvement to make these initiatives successful.

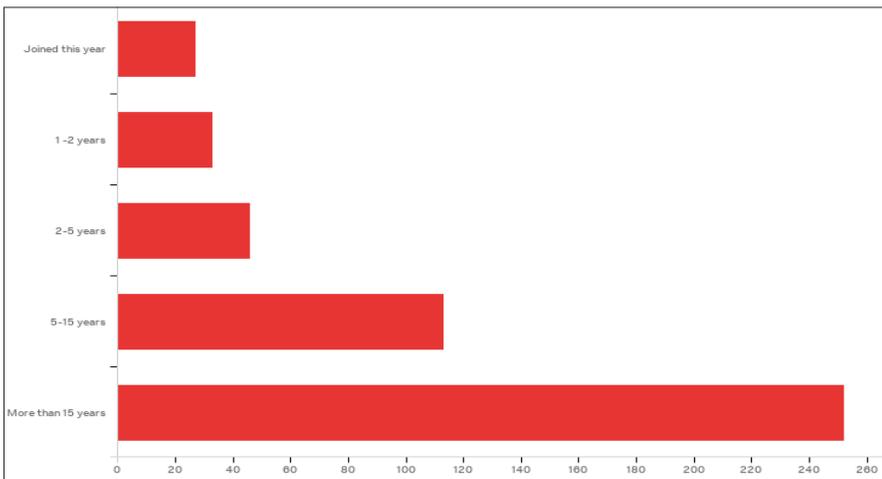
With what policy issues should FPS be involved and where is it likely to have an impact?



What specific actions should FPS take on these issues to inform the physics community and others and to promote discussion?



How long have you been a member of the FPS?



Greening the Global Economy

by Robert Pollin, *The MIT Press*, 2015, 176 pages; ISBN: 978-0262028233, \$22.95

Let me start with an admission. I am not a trained economist, nor am I well versed in the literature of environmental economics. Yet, as a historian of science with a joint appointment in the Physics and Astronomy Department and the Science, Technology, and Society (STS) Program at Vassar College, I often find myself navigating topics in my courses that take me away from my native expertise. In order to help set a solid foundation for STS class discussions, I'm always on the lookout for well written texts that put forward evidence-based arguments that can help students engage deeply and thoughtfully with complex topics. Robert Pollin's *Greening the Global Economy* argues that business as usual strategies regarding our energy policies are detrimental to our future. As a result, a significant re-envisioning of our global energy strategies and infrastructure will be necessary to stem anthropomorphic contributions to climate change. While this is by no means a novel argument, Pollin's latest contribution to the climate change debate is refreshing and compelling. A Distinguished Professor of Economics and Co-Director of the Political Economy Research Institute (PERI) at the University of Massachusetts-Amherst, Pollin effectively presents his work over the past decade analyzing and forecasting the costs and benefits of reducing our dependence on fossil fuels.

Oftentimes climate change debates seem to be polarized around zero sum games. If we want to stop global warming, we need to sacrifice our current standard of living and reduce our carbon footprint. This is called a "de-growth" argument. Using convincing economic models and some rhetorical judo, Pollin's argument challenges this zero sum assumption and proposes an alternative framework. Instead of arguing for the inevitability of de-growth to ensure humanity's future, Pollin argues boldly that a transition to a green economy over the next twenty years will actually stabilize global climate and make us more prosperous by "expanding human well-being" (p. 159).

Greening the Global Economy begins with a statement of the problem. In its latest report, The Intergovernmental Panel on Climate Change (IPCC) estimates that in order to stabilize the global average temperature, total greenhouse gas emissions will need to be reduced by 40% before 2035 and by 80% before 2050. With current global emissions (mostly CO₂) around 45 billion metric tons per year and growing, we are nowhere near on-track to meet these goals. Pollin argues that something must change from business as usual if we want to stem global warming. The rest of the book is dedicated to building out a plan that will allow a reduction of the global CO₂ emissions in line with the IPCC twenty-year target while simultaneously creating jobs and reducing global poverty.

Pollin's plan calls for a massive "global GDP clean energy investment project" (p. 19) that will "increase global investments every year in energy efficiency and clean renewables by 1.5 percent of global GDP ... and cut oil, coal, and natural gas consumption by 33 percent" (p. 92).

In Chapters 2-4 Pollin describes the current energy paradigm and what we would need to do to transform it. First he examines the environmental, economic, and political problems associated with switching over to nuclear power, expanding our reliance on natural gas, and investing in new technologies that allow for carbon capture and sequestration. Then Pollin outlines the two prongs advocated in his clean investment project: energy efficiency and clean renewables. In Chapter 5 Pollin finally gets to the crux of his economic forecasting model. He discusses the basic assumptions of his model and the results of its projections. In this chapter Pollin is walking a bit of a tightrope by including enough quantitative analysis to satisfy economists while not inundating the economic lay person in a sea of data. For readers interested in more details, Pollin takes care to include an expanded discussion of his model in an appendix.

In Chapters 6-8, Pollin justifies his proposed massive GDP investments, totaling \$30 trillion over twenty years, that will allow for an expansion of energy efficiency and a burgeoning of the clean energy renewables sector. Apart from stabilizing global temperatures, Pollin's investment plan forecasts a net increase in job opportunities around the world. While he is cognizant of the hardships the fossil fuel sector will encounter due to his investment plan, he claims these difficulties can be overcome with proactive programs that will help transition workers into new thriving economic industries. In Chapter 7 Pollin directly challenges the strategy of economic contraction or de-growth as a way to achieve the IPCC emission reduction goals. He shows how this approach will result in global economic hardship and still leave us short of the 40% reductions needed by 2035. Finally, Pollin concludes his argument for the global clean energy investment project by discussing the political will and ethical standards necessary for rolling his proposal out successfully and fairly.

Pollin's approach to discussing climate change seems sensible and grounded in rigorous analysis. He succeeds in reframing the zero sum climate debate and offering a promising alternative. While I have questions about assumptions within his model and how he projects the effects of technological innovation over the next 20-40 years, he is clearly aware of the pitfalls and highly contingent nature of economic forecasting. At one point he even quotes Ezra Solomon stating "the only function of economic forecasting is to make astrology look respectable" (p. 62). Ultimately, Pollin suggests that even if all the climate change models are wrong and the economic forecasts fail to accurately predict the future, we can justify his global clean energy investment project by thinking about it as humanity purchasing an affordable catastrophic insurance

policy. Pollin's outlook on the power of his global investment strategy may be too optimistic for some, but at least he has given us a rationally constructed and accessible model to grapple with and critique. I, for one, will be using Greening the Global Economy in my next STS seminar.

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The Renaissance of Renewable Energy

by Andrea Pagnoni and Stephen Roche, Cambridge, New York, 2015. 294 pp. \$30. ISBN 978-1-107-69836-9

I was intrigued by the title of this book because of all I had been reading about positive developments in the extraction of energy for humans from the Sun and wind; I was hoping to see these developments put into a systematized perspective. My appetite was further whetted by these opening words from the authors: "Whether one views climate change, population growth or resource depletion as the greatest threat to human survival, the basic problem is the same: there are limits to what our planet can provide or absorb. The renaissance of renewables is inevitable because sooner or later the oil, gas and coal will run out." (p. 1)

What I got instead was a general book about energy, with the first chapter describing how the energy concept was first formulated in terms of work as the product of force and distance and tracing the role of energy in history through the twentieth century. This was followed by chapters on forms and sources of energy, relative amounts of energy "used" for different purposes, the politics and economics of energy, and the environmental costs of "using" it. In the middle of these the longest chapter of the book describes all the specific sources of energy, including all the renewables. This chapter left me with the feeling that there's lots of energy out there, but it's not sufficiently concentrated to be accessed efficiently.

This characterizes renewable energy, the ostensible topic of this book, and the penultimate chapter leads to the same place. Echoing the enticing quotation from the first page of the book, it observes that twentieth century improvements in the quality of human life have come at the expense of Earth's ecosystems, but this cannot continue indefinitely. This sets us up for finding sustainable ways to enhance our quality of life

in the final chapter, which asserts that extricating ourselves from carbon-based energy and developing sustainable societies requires "the audacity ... to explore the outer reaches of the possible rather than the near shores of the probable." (p. 242)

The authors do this in the context of a plan by Mark Jacobson and Mark Delucchi whereby 0.59% of Earth's land surface provides the world's energy, with 51% coming from wind, 40% from solar, and 9% from tidal, geothermal (baseload) and hydro (peak load). Along with the transition to renewables is a requirement for greater efficiencies. For vehicular transportation, this means changing from the internal combustion engine to the electric motor, and the environmental consequences will depend on the energy source of the electricity. The only combustible fuel for transportation (presumably in the air) would be hydrogen. All new energy would be from renewable sources by 2030 and all energy would be from renewable sources by 2050. Thus in this book "the renaissance of renewable energy" is yet to come, although the authors note that the International Energy Agency revised its projected percentage of total energy from renewables in 2030 up from 14% to 25%.

I will close this review with two side comments, one negative and one positive. I would point out that neither of the authors has a background in physics (Pagnoni is an ecologist/environmentalist and Roche an editor/translator), and their book is punctuated with errors related to physics. Astute physicists will recognize these, but I am concerned that lay readers (who would seem to constitute the bulk of this book's audience) would not. The most serious errors are characterizing energy by "force, work, and power" (p. 6), understating the intensity of solar radiation by a factor of 100 (p. 11), stating that uranium "sheds neutrons" because it "has so many protons" (p. 36), implying that energy is stored in chemical bonds (p. 70), connecting photovoltaic panels with the same voltage in series (they should be in parallel!) (p. 113), and stating that the Energy Return On Investment of fossil fuels will increase as their supplies dwindle (p. 248). On the positive side, I would also point out that the authors have been very generous in providing photographs, graphs, and tables to supplement their text in making their points.

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