Developing the Next Generation of Women and Minority Scientists for the Nuclear Energy Industry

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Abstract: The largest source of carbon dioxide emissions globally is the combustion of fossil fuels (coal, oil and natural gas) in power plants, automobiles, industrial facilities and other sources. Generating electricity is the single largest source of carbon dioxide emissions, representing 41% of all emissions. Since 2007 the United States has been more actively considering nuclear power as an option for developing energy. Three decades after the Three Mile Island accident seemed to doom the nuclear power industry, the idea of a nuclear renaissance has been gaining public acceptance as a way to generate energy without greenhouse gas emissions and meet the nation’s electricity demands. The growth in the development of nuclear power will also require the development of new and diverse scientists in the areas of like health physics, chemistry, geology, environmental science, biology, and hydrology. This applied research paper looks at the critical importance of not just developing new scientists for the industry but also value of developing more women and minority scientists for the nuclear power industry through the development of viable solutions developed by women and men of color with industry experience. The focus of this approach for data collection is not to reconstitute theory but provide important practical information that can influence the world of practice, the engagement of industry, and the approaches of academia.

Keywords: Diversity in Science Careers

Introduction

AS A RESULT of significant concerns in many countries throughout the world regarding the rising price of automobile fuel, industry research needs to focus on the scientific development of new and environmentally clean energy sources that reduce reliance on fossil fuels and support the environmental importance of clean air (World Nuclear Association, 2009). At a time when the United States faces a projected 28 percent increase in electricity demand by 2035, failure to develop a holistic policy that meets the nation’s energy demands, security needs and greenhouse gas reduction goals could threaten progress toward these objectives (World Nuclear Association, 2009).

The largest source of carbon dioxide emissions globally is the combustion of fossil fuels (coal, oil and natural gas) in power plants, automobiles, industrial facilities and other sources. Generating electricity is the single largest source of carbon dioxide emissions, representing 41 percent of all emissions (World Nuclear Association, 2009). Many organizations are looking at nuclear power as an option for developing energy. Three decades after the Three

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Mile Island accident seemed to doom the nuclear power industry, the idea of a nuclear renaissance has been gaining public acceptance as a way to generate energy without greenhouse gas emissions and meet the nation’s electricity demands (Cho, 2010). This signals a revival in support for nuclear power in the West that was diminished by the accident at Chernobyl and also by nuclear power plant construction cost overruns in the 1970s and 1980s, coupled with years of cheap natural gas.

According to the World Nuclear Association (2009) the first generation of nuclear plants was justified by the need to alleviate urban smog caused by coal-fired power plants. Today’s driving forces for the growth of nuclear power include:

- Increasing energy demand: Global population growth in combination with industrial development will lead to a doubling of electricity consumption from the 2007 level by 2030. Besides this incremental growth, there will be a need to replace a number of old power plants (World Nuclear Association, 2009).
- Climate change: Increased awareness of the dangers and effects of global warming and climate change has led decision makers, the media and the public to agree that the use of fossil fuels must be reduced and replaced by low-emission sources of energy (World Nuclear Association, 2009).
- Economics: Increasing fossil fuel prices have greatly improved the economics of nuclear power for electricity. Several studies show that nuclear energy is the most cost-effective of the available base-load technologies (World Nuclear Association, 2009).

According to the Nuclear Energy Agency (NEA) (2007), the nuclear industry faces three particular problems: retaining existing skills and competences, particularly in countries which have not yet decided to replace existing, ageing facilities; developing and retaining skills and competencies in areas such as decommissioning and radioactive waste management; and, supporting a revival of nuclear power in countries wishing to do so with an ageing workforce and declining programs (Nuclear Energy Association, 2007). The (NEA) has unanimously adopted a statement on the need for qualified human resources in the nuclear field, reflecting their concerns about difficulties in recruiting qualified specialists in science: “If no action is taken on this issue, the nuclear sector risks facing a shortage of qualified manpower to ensure the appropriate regulation and operation of existing nuclear facilities as well as the construction of new ones in those countries wishing to do so,” (Nuclear Energy Association, 2007). The NEA delivers suggestions to its member governments. First, it suggests that regular assessments be performed of both the requirements and the availability of qualified human resources to match identified needs. Secondly, governments, academia, industry and research organizations should collaborate both nationally and internationally. Thirdly, governments, whether or not they chose to use nuclear energy, should encourage large, high-profile, international research and development programs (Nuclear Energy Association, 2007). The challenge of North American countries and the world is to develop and maximize the collective intellectual capital and the knowledge of best minds in scientific fields such as health physics, chemistry, geology, environmental science, biology, and hydrology to work with technology, engineering, and mathematics. The reality is that these best minds should also include women, the disabled, Latino Americans, Native Americans, and African Americans. New breakthroughs and energy efficiencies require scientific professionals with diverse ways of working, thinking, and learning to participate and engage in
nuclear power environmental areas. For the United States and Canada, it means that continued technological leadership depends on the healthy development of environmental scientists that represent all their citizenry.

In Canada, the Ontario government has decided to refurbish and restart four reactors, adding 25 years to its operating lifetime as a step in the plan to expand its nuclear fleet. In the United States, there have been 17 applications to the Nuclear Regulatory Commission (NRC) for joint construction and operating licenses for about 25 new nuclear power reactors, and it is clear that there will be significant new nuclear capacity by 2020 (World Nuclear Society, 2010).

**The Increased Need for New Environmental Scientists**

Universities that develop environmental scientists in the United States and Canada are at a critical stage as the world faces unprecedented challenges. Global economies and conditions are changing rapidly. Many of these vital, exciting and challenging problems are characterized by increasing complexity, ambiguity, uncertainty, and rapidly changing conditions. Among these problems are biodiversity, ecosystems, environmental pollution, and communicable diseases, requiring a high level of creative talent, especially as the United States and Canada experience increasing diversity and ethnic immigration. Solutions to these problems require the best minds and facilities to work together. The concept of sustainability within environmental science has caused new fields to emerge in which scientists have to learn to bridge, blend, and integrate traditionally separate fields.

Professional science Master’s degree programs

The reality of changing demographics has also created a need to include multiple means and intelligences to produce the best environmental scientists for the nuclear energy industry. Their roles would be to evaluate environmental threats, policy issues, and conduct critical research. The reality is that there needs to be a pipeline of new students and new professors in environmental science to meet the growth of the nuclear power use in the United States and Canada. Several universities are developing innovative graduate programs that could make a resounding impact if they were to recruit additional women and minorities into the programs and then develop them as faculty members after program completion.

Green Mountain College’s distance learning Master of Environmental Science degree combines the best of online learning with intensive locally applied experience. The university promotes the program as “a bioregional approach to distance education”. Rather than learning about environmental studies solely through examples in a textbook, students in each of the courses use their local ecosystems as laboratories in which to experiment with new concepts and skills. The program requires one residency per year, using its residencies to build relationships and integrated learning among students, faculty, and scholars in residence. Course students span the United States and the globe, bringing a breath of perspectives and experiences not available to masters programs that draw the majority of their students from the same geographic area.

American Public University offers a low cost, on-line Master of Science Degree in Environmental Policy and Management. Students study ecosystems management, the impact of industrialization on the environment, economics and resource availability, regulation and law, environmental ethics, landscape-level conservation, political ecology, and environmental
technology and management. They also have the opportunity to focus on several emerging fields of study, including global environmental change, environmental planning, and environmental sustainability, as well as to explore a general study option. This degree is applicable for government and industry environmentally-related professions. It also can serve as a foundation degree for study at the doctorate level in related fields.

Virginia Tech offers an innovative graduate program in National Resources and Sustainability. The Executive Masters in Natural Resources and Sustainability (XMNR) allows those who work full time to attend courses one weekend a month at its Northern Virginia Graduate Center just outside Washington, D.C. and complete a graduate degree in 18 months. The program is designed to encourage breadth in environmental sciences and depth in a chosen area of scientific concentration, such as such as environmental public policy, marine ecosystems, biodiversity, toxicology, hydrology and chemical cycling, or climate change. The program concludes with a ten-day residency focused on environmental policy in China.

Students enrolled in Duke University’s Environmental Leadership Master of Environmental Management (DEL-MEM) tackle real-life case studies individually and in groups, containing problems and solutions directly related to their current jobs, in a theory-to-application environmental science program. “Leadership in Environmental Management” is a central theme incorporated throughout the DEL curriculum.

Antioch University New England offers an executive MS degree in Environmental Studies with a concentration in Sustainable Development and Climate Change (SDCC). This program integrates courses in environmental science, social science, and organizational leadership.

The programs described above meet the classification requirements of a Professional Science Master’s program (PSM). The PSM is intended for math and science graduates focused on careers at the intersection of science and management. In large public and private enterprises, graduates serve as lab and project managers and/or work in close collaboration with specialists in finance, intellectual property or regulatory affairs. In smaller startups, they carry responsibilities in both science and management. And in the public sector, their value is just now beginning to be recognized (Tobias, 2009).

The Professional Science Master’s (PSM) degrees are innovative graduate degree programs designed to allow students to pursue advanced training in science or mathematics, while simultaneously developing workplace skills highly valued by employers. At the heart of the PSM is the combination of graduate-level sciences and/or mathematics, often in a newly emerging discipline (such as bioinformatics) or at the intersection of two or more traditional ones (Tobias, 2009). Professional Science Master’s programs usually consist of two years of academic training in an emerging or interdisciplinary area, along with a professional component that may include internships and “cross-training” in workplace skills, such as business, communications, and regulatory affairs. These programs have been developed through academic collaborative partnerships between industry professionals and research faculty to provide viable graduate-level academic training to meet future industry and societal needs (Tobias, 2009).

Value to Women and Students of Color

University faculty and deans have engaged local employers in identifying future employment opportunities for master’s level science and mathematics graduates. Students (especially women) find the programs attractive because they can often be completed in two years or
less, often do not require graduate aptitude admission tests, and are offered in flexible formats that can suit women who are transitioning from stay-at-home motherhood (Tobias, 2009). The programs’ short completion times and flexible schedules are quite significant for African American women, many of whom are single parents. According to the U.S. Census Bureau (2009), 62 percent of African-American households are headed by single women. This has had dramatic implications with regard to the development of African-American women as scientists, faculty members, and mentors for other African-American students who could find inspiration in others who look like themselves in the classroom and in industry.

One of the first steps toward addressing the growth of nuclear energy is ensuring that there is marketing outreach and partnerships that make these programs more diverse. Non-governmental organizations (NGOs), think tanks, non-profits, and governmental agencies are facing challenging times in this current global economic crisis. They are facing a wave of retirements from members of the “Baby Boomer” generation and are attempting to develop the next generation of global environmental leaders. It is incumbent on this next generation of environmental scholars and practitioners to include more ethnic, racial, and cultural minorities (Burrell, 2009).

Environmental programs such as those described previously, could benefit minorities by grooming them for future positions in the environmental science faculty through mentorship and faculty development programs. The diversification of the student body and development of a diverse faculty can result in a dramatic impact on society through the study of issues that are germane to minority communities (Burrell, 2009).

Amplified globalization, enlarged technology, and increased immigration can yield substantial benefits to solving environmental and energy problems. Diversity brings about differences in style and perspectives, helping organizations and universities find new methods of problem solving which have dramatic impact on the study of science and society. Diversity means differences, and differences create challenges, but differences also open avenues of opportunities (Blank & Slipp, 1994). According to Burrell (2009), the benefit of culturally and racially diverse student populations in non-traditional and executive environmental programs includes:

1. Enabling a wide range of views to be present in a learning community, including views that might challenge the status quo from all sides.
2. Considering the impacts of actions and policy decisions on minority communities.
3. Involving student participants with a vested interest in researching and solving environmental issues like environmental racism that directly influence their own communities.
4. Creating a pipeline for future environmental faculty members of color (Burrell, 2009).

Gainen and Boice (1993) outlined the importance of mentoring and developing minority students and minority faculty. This mentoring process requires structure, commitment, and effort. Moore and Amey (1988) define mentoring as a form of professional socialization whereby an experienced individual serves as a guide and role model to a less experienced organizational member for the purposes of developing their skills, abilities, and cultural understanding of the institution. Hill, Bahnuik, and Dobos (1989) focus on the communication aspects of the relationship. Stanley and Lincoln (2005) argue that mentoring is a relationship “characterized by trust, honesty, and a willingness to learn about self and others, and the ability to share power and privilege” (p. 46).
According to Gainen and Boice (1993) mentoring can be considered an activity in which a perceived locus of causality, from the perspective of the mentee, is external, given that member(s) of an organization can influence a mentee’s actions, behaviors, and developmental processes. In other words, mentoring can be viewed somewhat as an externally imposed practice that socializes or “compels” a mentee to understand and accept the norms of his/her socializing group or risk being denied permanent entry (i.e. career choice, graduate program discipline choice, or the choice to become a science faculty member).

It is critical for the nuclear power industry and university departments to realize that they must have successful students before they can have successful industry professionals and faculty. This requires a commitment to developing new methods to cultivate new female and minority environmental science talent. Today nuclear energy is back on the policy agendas of many countries, with projections for new building similar to or exceeding that of the early years of nuclear power. This growth will require new professionals with the expertise and training to consider the environmental and biodiversity implications of the increased use and growth of the commercial use of nuclear power.

**Method**

Focus groups were conducted to gather data from those with nuclear power industry experience; groups of 24 total participants were recruited from the 2010 U.S. Nuclear Regulatory Commission’s (USNRC’s) Regulatory Information Conference (RIC). The table below lists some of the technical presentations made during 2010 RIC.
The 24 participants included 12 African-American participants (2 females and 10 males) and 12 Latino-American participants (3 females and 9 males). All participants held degrees in a science-related area, worked in an environmental studies area in the nuclear power industry, and had over 5 years experience in the industry. The goal was to consider the best ways to develop more women and minority scientists for the nuclear power industry. The focus of this approach for data collection was not to reconstitute theory, but to provide important practical information that could influence the world of practice.

There are a plethora of traditions in which focus groups provide a viable way to develop collective new knowledge, solve problems, and produce data. Vaughn, Schumm, and Sinagub (1996) outline practical values for using focus groups:

1. Focus groups can help to generate solutions to real organizational problems through their collective shared experiences.
2. Focus groups are often conducted to assist with program development, program implementation, and program development (Vaughn, Schumm, & Sinagub, 1996).
Focus groups can provide avenue to investigate how opinion and feedback are assembled, as well as how they are articulated (Barbour and Kitzinger, 1999). Focus group information can unravel relationships and nuances of how experiences, ideas, and attitudes function within a specific certain cultural setting.

Focus groups:

1. Have the ability to function as an effective inquiry method if the research queries to be addressed entail collecting a variety of experienced viewpoints.
2. Can offer a road map to solving real world problems based on feedback gained from the collective knowledge and experiences of the group’s participants.
3. Suggest that group brainstorming and group discussions help people to be more honest and more collaborative in the context of their responses (Barbour and Kitzinger, 1999).

The focus groups in the current study were asked a series of questions. Each group was required to “brainstorm” and generate answers based on their viewpoints, opinions, and experiences concerning the development of more women and scientists of color for the nuclear power industry. Answers were recorded on flip charts and each group provided a presentation to explain their answers. After the answers were explained they were divided into similar categories. Duplicate responses were eliminated. Focus group responses were recorded and grouped around key labels, which were in turn categorized into broader concepts. Categories were then deconstructed to examine the connections between labels and categories. The final stage of analysis involved establishing core categories to which all other categories were related and integrated into connected groups that were listed on flip carts for reference. Each focus group participant was then asked to select from the final response categories listed on the flip charts. This is a method outlined as effective by Vaughn, Schumm, & Sinagub (1996).

Results

The focus groups were allowed to discuss and engage the key question for one hour. The groups recorded their collective results on their individual group flip charts. Each group presented, explained, and clarified the conclusions that were recorded on the flip charts. Duplicates from the groups were eliminated to create a final list of the collected responses. In the final step, the focus group participants picked the top ten responses. The final responses were based on participants’ selections of their choice of the top ten options, founded on a collective vote of the total group.

What are the steps that can be taken to develop more women and minorities scientists of color for the nuclear power industry?

1. The nuclear power industry could partner with minority-serving K-12 public schools to develop curricula, field trips, and educational opportunities to get students interested at an early age.
2. The nuclear power corporations could provide funding for minority-serving and women’s colleges and universities (University of Puerto Rico, Trinity University, Washington, D.C., Spelman College, Morgan State University, Hampton University, North Carolina A&T, and South Carolina State were specifically mentioned by name) to develop rel-
evant courses, undergraduate degrees, graduate degrees, executive graduate programs, on-line programs, and doctoral programs.

3. The nuclear power industry could provide scholarships and grant funding for minority students to cover costs of attending executive programs and traditional programs of the students’ choice at any university that offers a suitable program.

4. The nuclear power industry could fund the development of mentor programs for students of color that pair them with a faculty and an industry mentor to provide systems of support during the time they are students.

5. The government and corporate nuclear organizations could provide student loan repayment for graduates who take positions in the nuclear power industry after graduation.

6. The nuclear power industry could develop career-planning courses that educate students on their career options in the nuclear power industry. The nuclear power industry could fund student memberships for students to be members of the American Nuclear Society, Association of Blacks in Energy, Association of Black Geologists, SACNAS (society of scientists dedicated to advancing Hispanics/Chicanos and Native Americans in science), National Society of Black Physicists, the Society of Mexican American Engineers and Scientists (MAES), National Society of Hispanic Physicists, the National Organization for the Professional Advancement of Black Chemists, and the Association of Women in Science.

7. Members of nuclear energy associations could provide funding for minority and women students to attend association training and conferences. This could include programs intended to offer unique opportunities for economically disadvantaged high school and college students to participate in summer research experiences with a scientist in a laboratory setting. Students would be given a stipend for their ten-week participation. This financial support is critical, as a lack of this support would likely force these students to seek other means of summer employment to assist with family finances.

8. Members of the nuclear power industry could provide grant funding opportunities for urban and minority serving community colleges.

9. Members of industry could fund faculty sabbaticals for minority faculty members to become scholars-in-residence for corporations and associations affiliated with the nuclear power industry, allowing them exposure to the most current practical industry experiences.

10. Members of the nuclear power industry could support and fully fund diversity conferences in the sciences that would emphasize the importance of diversity to non-minority industry executives, faculty, and government leaders.

**Conclusion**

The growth of nuclear power requires innovation and creativity. Investment in a more diverse scientific workforce advances the attainment of this goal that is so vital for government, industry, and academia. Success requires a pooling of resources and a commitment to novel ideas, programs, methods, and participants. Within universities, partnerships must engage professional educators from schools and departments of education who are expert in teacher training and innovative curriculum design with appropriate content-expert faculty from science disciplines who share the vision of a need for enhancing the diversity of the science disciplines. These multi-disciplinary teams must include staff from offices of student affairs in
consultation with minority-serving student organizations that can advise on the specific needs and concerns of minority students. It is only through knowledge sharing, multi-stakeholder collaboration, multi-university partnerships, and the intentional formation and sustained support of partnership programs that the nuclear power industry and university programs can expect to achieve the diverse and talented science workforce required to respond to the environmental and global challenge of meeting rapidly growing energy demands.
References


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Dr. Darrell Norman Burrell is a post-doctoral student. He has a doctorate in health Education from A.T. Still University in Environmental Science and Health. He is a faculty member at Virginia International University and A.T. Still University. He teaches as an adjunct faculty member in the “Green” MBA in Sustainability Development with Marylhurst University. He is also a Presidential Management Fellow, www.pmf.gov with over 15 years of management experience. He has an EdS (Post Master’s Terminal Degree) in Higher Education Administration from The George Washington University. He has graduate degrees in Human Resources Management and Organizational Management from National Louis University, and a graduate degree in Sales and Marketing Management from Prescott College. He has over 27 publications and has presented over 20 peer reviewed conferences.

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This knowledge community is brought together to address a common concern for disciplinary and interdisciplinary challenges in the sciences, and in particular the relationships of science to society. The community interacts through an innovative, annual face-to-face conference, as well as year-round virtual relationships in a weblog, peer reviewed journal and book series—exploring the affordances of the new digital media. Members of this knowledge community include academics, scientists, social scientists, university managers, science administrators, policy makers, researchers and research students.

Conference

Members of the Science in Society community meet annually at the International Conference on Science in Society, held annually in different locations around the world. The Conference was held at the University of Cambridge, UK in 2009; at the Universidad Carlos III de Madrid, Madrid, Spain in 2010; and at the Catholic University of America, Washington DC, USA in 2011. In 2012, the Conference will be held at the University of California, Berkeley, USA.

Our community members and first time attendees come from all corners of the globe. The Conference is a site of critical reflection, both by leaders in the field and emerging scholars. Those unable to attend the Conference may opt for virtual participation in which community members can submit a video and/or slide presentation with voice-over, or simply submit a paper for peer review and possible publication in the Journal.

Online presentations can be viewed on YouTube.

Publishing

The Science in Society Community enables members to publish through three mediums. First, by participating in the Science in Society Conference, community members can enter a world of journal publication unlike the traditional academic publishing forums—a result of the responsive, non-hierarchical and constructive nature of the peer review process. The International Journal of Science in Society provides a framework for double-blind peer review, enabling authors to publish into an academic journal of the highest standard.

The second publication medium is through the book series Science in Society, publishing cutting edge books in print and electronic formats. Publication proposals and manuscript submissions are welcome.

The third major publishing medium is our news blog, constantly publishing short news updates from the Science in Society Community, as well as major developments in the field. You can also join this conversation at Facebook and Twitter or subscribe to our email Newsletter.
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