Increasing Diversity in Energy Efficiency Professions: JUMP into STEM

Mary Hubbard, U.S. Department of Energy, Building Technologies Office
Dr. Kim Trenbath, National Renewable Energy Laboratory
Melissa Lapsa, Oak Ridge National Laboratory
Dr. Roderick Jackson, National Renewable Energy Laboratory

ABSTRACT

A long-term approach to achieving equity in the energy efficiency industry is to increase the overall diversity of the professionals who work in the field. Building science professionals have a direct impact on energy efficiency policy and programs, as many become leaders within the industry. Buildings are used every day by almost all members of U.S. society, so diversity in building science professionals is critical to better understanding the behaviors and needs of the full spectrum of building occupants. Many groups of people, including minorities and women, are underrepresented in the industry. The industry needs to attract a wide range of current college and university students to careers in building science, so that many perspectives are included in the clean energy transition.

The JUMP into STEM student competition addresses this need by inspiring students from diverse backgrounds to use creative ideation to solve real-world building science problems. Student teams—comprising an interdisciplinary mix of majors and underrepresented groups in **s**cience, **t**echnology, **e**ngineering, and **m**ath (STEM)—respond to one of three buildings-related challenges. Diversity is encouraged through challenge design, competition guidelines, and evaluation criteria for the submission. Winners of the competition are awarded paid building science internships, a gateway to a career in this field. The competition has an advisory panel of diversity experts and a professor team that includes representation from minority-serving institutions.

This paper presents the JUMP into STEM approach to fostering diversity and creative ideation on technical challenges and discusses outcomes from the 2019 and 2020 competitions.

Introduction

Energy efficiency professionals are essential to leading the transition to the clean energy economy; however, the industry is underrepresented by groups—including, but not limited to, those based on race, ethnicity, and gender (Pearl-Martinez and Stephens 2016). In 2018, 24% of the energy efficiency workforce were women and 8% African American, while the national workforce averages were 47% women and 12% African American. Sixteen percent of the energy efficiency workforce was Hispanic and Latino, compared with 17% nationally (Barrett and Yadken 2019). Energy- and efficiency-related policies impact people of all backgrounds, and underrepresentation contributes to the lack of equity in the energy efficiency industry. A long-term approach to achieving energy efficiency equity is to increase the overall diversity of professionals who work in the field. People from diverse backgrounds bring understanding, empathy, and perspective to energy efficiency challenges that result in practical solutions for all stakeholders (Mannix and Neale 2005). The competition described in this paper addresses the lack of diversity in professional ranks by targeting diversity in building science students.

Building science professionals make up a significant portion of the energy efficiency industry. Building science is an interdisciplinary study of the way that buildings interact with

occupants, natural surroundings, other buildings, and other infrastructure such as the electrical grid and transportation systems. A key focus of this interaction is the flow and use of energy and natural resources (water, carbon, etc.) within the built environment. The traditional training pathways for building science professionals are mechanical engineering and electrical engineering, but building science and academic disciplines are evolving. Looking forward, building science will require a broader discipline base that includes engineering, physics, chemistry, biology, and math; computer science, economics, meteorology, and climate science; as well as the social sciences, like sociology, psychology, anthropology, and public policy. There is a need for nonengineering departments to expose their students to the holistic building sciences and to encourage more students to pursue building science careers.

Similar to the need to attract a multidisciplined workforce, there is a need to recruit a building science workforce from diverse backgrounds, including women, racial minorities and representation from different socioeconomic statuses. These groups are broadly underrepresented in **s**cience, **t**echnology, **e**ngineering, and **m**ath (STEM). Building science professionals have a direct impact on energy efficiency policy and programs, as many become leaders within the industry. Buildings are used every day by almost all members of U.S. society, so diversity in building science professionals is critical to better understanding the behaviors and needs of the full spectrum of building occupants.

In the future, building science will rely on a much broader set of experiences and skill sets. Buildings serve communities, and as buildings evolve, they must be able to meet the needs of and offer solutions for their occupants. Decision-making panels, whether for energy efficiency policy or zero energy community design, need to be diverse so they represent different stakeholder perspectives. Diversity includes both background and discipline; the student competition detailed in this paper tackles equity by encouraging underrepresented groups to pursue building science and future industry needs by encouraging students from a variety of majors to solve building science problems.

The number of jobs in the energy efficiency sector is growing. In 2019, energy efficiency employers predicted an 8% growth rate (from 2018 to 2019) for employment (Barrett and Yadken) . The same report identified hiring difficulty for engineers and scientists, managers, designers, and architects, indicating a need for well-educated workers. Attracting students to the building sciences while they are in undergraduate or graduate school helps establish the foundation for an increased number of people in the building science workforce. College and university students are at a point in their lives where they are exploring career possibilities. Many students work as interns during their summers or select parts of the school year to gain professional work experience and to better understand what career paths to choose.

Prior research documents strategies for encouraging students, including those from underrepresented groups, to pursue and continue studies and careers in STEM. Exposure to STEM careers through K-12 field experiences can trigger students' interest. Clarke et al. (2019) found that students who attended a medical school workshop expressed interest in career-related content in addition to scientific content, so exposure to real-world science work can spark short-term interest in STEM careers. Ozogul et al. (2019) found that engineering-related workshops during a K-12 field trip improved student perceptions towards engineering, yet prior to the event, Caucasian students had higher self-efficacy and lower negative stereotypes than Hispanic students. For girls and women, female role models and mentors have a positive influence. In order to form STEM-identity in girls, strategies should include combining inclusive curriculum and pedagogies with exposure to female role models (Prieto-Rodriguez et al. 2020). Dennehy

and Dasgupta (2017) completed a longitudinal study on the impact of mentoring on women in engineering programs during their first two years of college, and found that female mentors, as opposed to male mentors or no mentors, protected women's sense of belonging in engineering, self-efficacy, motivation, retention in engineering majors, and post-college engineering aspirations. The study concluded that same-gender peer mentoring at this point in female students' lives promotes women's success and retention in engineering. Similarly, mentorship plays an important role for underrepresented students' success in undergraduate and graduate STEM programs. Ceglie (2020) found success factors for women minority students include advising, mentoring, and networking; the importance of a supportive inviting environment; and targeted support program. Byars-Winston et al. (2011) identified practices that increase the likelihood that underrepresented minority graduate students completing graduate school, including mentor training for research advisors, student career coaching, and individualized career development plans.

JUMP into STEM is a college and university student competition sponsored by the U.S. Department of Energy (DOE) Building Technologies Office. The goal of the competition is to inspire students from diverse backgrounds to use creative ideation to solve real-world building science problems. Student teams, made up of an interdisciplinary mix of majors, respond to one of three buildings-related challenges. Diversity is encouraged through challenge design, competition guidelines, and evaluation criteria for the submission. The challenges are designed to be relatable to students from a variety of perspectives, and some aspects of diversity—like gender balance, a team's unique perspective, and their interdisciplinary mix of majors—are considered in the scoring. The competition management organized a professor team, which includes representation by minority-serving institutions and historically black colleges and universities (HBCUs). The professor team encourages students to participate by incorporating the challenges in coursework. Student winners of the competition are awarded paid building science internships at one of two national laboratories, a gateway to a career in this field. The competition also has an advisory panel of diversity experts.

This paper presents the goals that the JUMP into STEM management team set out to address and how the competition fosters diversity along with creative ideation on technical challenges. The paper also highlights outcomes from the 2019 and 2020 student competitions.

Background

The JUMP into STEM competition combines two mission statements, which together make the competition unique:

1. Increasing the number of students involved in building science
2. Increasing the diversity of students involved in building science.

Both are addressed through the university student competition. There are other Building Technologies Office-sponsored student competitions; a well-known one is the U.S. Department of Energy Solar Decathlon®, which exposes students to building science and zero energy design through two challenges.[1] The Solar Decathlon Build Challenge requires teams to design and build a home that is zero energy ready (DOE 2015); this challenge runs approximately two years per cycle. For the Solar Decathlon Design Challenge, student teams design a residential or

[1] For more information on the Solar Decathlon, see: https://www.solardecathlon.gov/

commercial building that is zero energy ready (DOE 2015); this challenge often requires up to a semester and a half of work. University professors have offered participation in the Solar Decathlon Design Challenge as a senior capstone project. Both challenges are successful in encouraging more students to learn about energy-efficient building design and building science.

JUMP into STEM is a complementary competition to the Solar Decathlon challenges. JUMP into STEM is online until the final event, with college and university professors providing instruction related to the challenges in the classroom. It is also far less time-consuming for students than competing in other DOE challenges. Each student team competing in JUMP into STEM writes a five-page paper that details an innovative idea in response to a current building-science challenge. The challenge is less than a semester long and can be integrated into a single semester's coursework as part of the student's grade. An informal student competition trajectory is beginning to develop, where students first get involved in a building science competition through JUMP into STEM and later progress to Solar Decathlon Design and/or Build Challenge.

The acronym "JUMP" stands for **J**oin the discussion, **U**nveil Innovation, **M**ake connections, and **P**romote tech-to-market. Before JUMP into STEM was a student competition, it was an industry-focused competition where selected emerging entrepreneurs responded to technical challenges. Winners received cash awards from companies sponsoring the challenges and technical support from national laboratories to help further their innovative ideas. Today, the competition focuses on university-level students to introduce interested students to this field of study, hopefully increasing the number of students pursuing related jobs after graduation. Building science or architectural engineering is not a common academic offering—only a handful of schools, including the University of Colorado, Pennsylvania State University, Purdue University, Massachusetts Institute of Technology, and Carnegie Mellon University offer architectural engineering programs.

Building science is an interdisciplinary field, and includes professionals with different degrees, such as engineering, architecture, computer science, economics, meteorology, sociology, policy, and communications. Engineers and architects work together on design-build projects to ensure that energy-efficient strategies are incorporated into building construction. Computer scientists and other algorithm experts develop smart technologies to improve building operations. As the world becomes more data-driven, individuals from analysis-minded fields like economics and meteorology will contribute to predictive models for buildings. Social science fields will be more heavily relied on to understand occupant needs. Policymakers need to understand the energy and societal impacts of their decisions on building occupants.

Vision and Goals

JUMP into STEM incorporates strategies to help the competition reach its desired diversity and participation goals. An important strategy includes developing an overarching vision and subsequent goals for JUMP into STEM to guide the competition process and structure. The vision and goals are:

> The JUMP into STEM initiative seeks to inspire the next generation of building scientists, focusing on creative ideation and diversity in the building science field. The diversity objective is inclusive of an interdisciplinary mix of majors and underrepresented groups in STEM.

The JUMP into STEM initiative will:

- Attract students to building science, including students representing an interdisciplinary mix of majors and underrepresented groups, including but not limited to those based on race, ethnicity, and gender.
- Team with professors from a variety of disciplines to provide a launch pad for creative building science challenges in the classroom
- Inspire entrepreneurial cross-disciplinary collaboration on building science challenges at colleges and universities
- Collaborate with industry partners and STEM organizations to design and promote motivational student challenges and events.

This vision and goal statement guides the competition design to be mindful of ways to encourage diversity.

The Competition

JUMP into STEM is jointly managed by DOE's Building Technologies Office, Oak Ridge National Laboratory (ORNL) in Oak Ridge, Tennessee, and the National Renewable Energy Laboratory (NREL) in Golden, Colorado. JUMP into STEM offers college and university student teams the opportunity to respond to a relevant building science challenge in the form of an essay. Students are required to be on a team of at least two students, and teammates must represent at least two different majors. Gender balance is encouraged and rewarded during the judging through transparent evaluation criteria. The topics are real-world challenges that building researchers are currently tackling. Example challenge topics include innovative residential building envelope retrofit solutions; novel solutions to utilize residential sensor data and coordinate controls; unique heating, ventilating, and air conditioning designs for small commercial buildings that preserve air quality; and new automated fault detection and diagnosis algorithms for commercial buildings. Student teams are tasked with identifying a stakeholder community and framing the challenge based on that community's unique needs. The students then develop an innovative solution to the challenge, report their solution in a five-page essay (appendix optional) and develop a technology-to-market plan.

JUMP into STEM has run as a national competition for the last two years. During both years, the competition offered three challenges; competitors choose which challenge they would like to address. The competition offers multiple webinars with presenters from both research (national laboratories) and industry backgrounds for students to learn about each of the topics in depth.

After the submission closing date, each challenge is evaluated by a unique panel of three judges, who have expertise in the specific topic. Judges come from industry, academia, and national laboratories. The judges evaluate submissions using predetermined evaluation criteria (see Appendix A) that is transparent to the student participants. The scoring from these evaluations guides the selection of challenge winners. Challenge winners are invited to participate in a final competition located at one of the two organizing national laboratories.

At the final, in-person competition event, students present their ideas to a panel of three judges, different from those who judged the online challenges. A similar rubric (see Appendix B) is used to evaluate the presentations and guide the selection of the winners. While the judges are scoring and making the final selection of winners, students tour the national laboratory facilities

and network with the competitors from other schools. Winners of the final competition earn a 10-week paid summer internship at either NREL or ORNL.

During the internship, students work alongside national laboratory research mentors, many of whom have advanced degrees in their field. Students directly contribute to the national laboratory's building science research projects and present posters of their work during an intern poster session toward the end of their internship.

Intentional Development

JUMP into STEM was intentionally designed to meet the vision of attracting students who are underrepresented in STEM and students from an interdisciplinary mix of majors, while at the same time increasing overall student participation. All students enrolled in U.S. colleges and universities are eligible for participation. The evaluation challenges, criteria, and judge selection were also developed with diversity in mind:

- Challenges include aspects that appeal to students from various backgrounds. For example, the wall retrofit challenge focused on health issues and energy waste due to leaky and unhealthy walls. When this challenge was used during an in-person mini-hackathon event, a student from Puerto Rico who experienced Hurricane Maria shared his personal experiences about mold growth in buildings.
- Diversity of thought is a category of evaluation criteria along with technical aspects and innovation of the idea itself. The criteria include an evaluation of how well the students used their personal perspective to address, understand, and solve the problem. Criteria are displayed on the challenge descriptions. See Appendices A and B for the list of evaluation criteria.
- The competition management is mindful of putting together judging panels for both the online challenges and the in-person, final competition event with representation from women and minorities, so that these perspectives contribute to winner selection.

Targeted Outreach

JUMP into STEM is marketed through social media and large email listservs made up of thousands of students, professors, and other individuals. The management team also reaches out to contacts at colleges and universities for more personal recruitment.

Minority-serving institutions are institutions of higher education enrolling populations with significant percentages of undergraduate minority students.[2] They include HBCUs, which are nationally accredited colleges and universities that were established prior to the Civil Rights act of 1964 to primarily serve the educational needs of black Americans.[3] To reach the diversity goals of the competition, JUMP into STEM recruits students from minority-serving institutions and HBCUs by reaching out to professors at these colleges and universities. Targeted professors are those who had previous collaborations with national laboratories, including those who have mentored student teams for the Solar Decathlon Design Challenge. Other outreach channels include using broader minority-serving institution networks to reach others who do not have existing collaborations with the national laboratories.

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[2] https://www2.ed.gov/about/offices/list/ocr/edlite-minorityinst.html
[3] https://www2.ed.gov/about/offices/list/ocr/docs/hq9511.html

JUMP into STEM works closely with many professor contacts to encourage them to include the challenge in their courses. This work is done both individually through small group phone discussions and through the organization of a professor team.

The competition has integrated some of the challenges into other in-person hackathons and organization events. For example, a JUMP into STEM challenge on residential data was offered at the American Association of Black Engineers hackathon at New York University in November 2018. The team who chose to work on the residential data challenge won the hackathon. JUMP into STEM's residential building envelope retrofit challenge was also modified and run as a mini-hackathon at two NREL "Mini-Semester" conferences (January 2019 and January 2020), which are three-day conferences that aim to expose students who have applied to DOE-funded internships to the research at NREL. The mini-hackathon supported the mini-semester's goal of providing experiential opportunities for students in STEM to learn about the wide range of research being conducted at NREL, help them understand different pathways to scientific careers, and provide networking opportunities with the NREL scientific community and administrators. Integrating the JUMP into STEM challenges into these events exposes many students to innovative buildings-related work.

Advisory Board

Developing a student competition to encourage diversity in building science benefits from expert advice. As such, the JUMP into STEM management team established an advisory panel of experienced leaders in university and diversity initiatives. The current JUMP into STEM advisory panel includes:

- Dr. Ellen Morris, Director University Partnerships, National Renewable Energy Laboratory
- Dr. Desmond Stubbs, Director, Diversity Initiatives, Oak Ridge Institute for Science and Education
- Dr. Moody Altamimi, Director, Office of Research Excellence, Oak Ridge National Laboratory
- A Senior Advisor for Facilities, Directorate for Geosciences, National Science Foundation; former Professor of Atmospheric Sciences, University of Colorado; former director of the Miramontes Arts and Science Program (undergraduate program for motivated traditionally underrepresented and/or first-generation students), University of Colorado.

The advisory board provides advice on the design of the competition, reviews the challenges and the evaluation criteria, and makes helpful suggestions to ensure the success of the program. A selection of the advisory board's suggestions includes:

- Post JUMP into STEM's meaning of diversity on the website.
- Encourage the inclusion of the competition as an integrated part of a college course or seminar to institutionalize the competition at the college. Other ways to institutionalize are to integrate into organizations such as the National Society of Black Engineers, the Society of Women Engineers, and the Association of Women in Architectural Design.

- Require student teams to identify a mentor within their school who can help students with their submission and allow the competition management to build a relationship with the school through the mentor.
- Require student teams to represent at least two college majors.
- Include diversity evaluation criteria and include gender balance as an evaluation criterion, where more balanced teams received more points.
- Include evaluation criteria that captures value from perspectives and skills of contributors in diverse teams. For example, the advisory board suggested the criteria: "Based on the idea submitted, do the students bring a unique perspective to the problem?" and "Do the students understand these stakeholders' needs?"
- Ensure that evaluation criteria are transparent to all competitors, including the diversity-related criteria.
- Ask students to define the problem they are trying to solve and identify the community of need as part of the submission.
- Market and outreach through social media postings and other non-email means such as working with organizations and societies as well as communication offices, career centers, graduate student affairs offices, and national laboratories' communication offices.

Professor Team

A best practice for increasing student participation in the competition is to integrate the challenges into college course curriculum. A professor team was established with the idea that professors on the team would work to add a JUMP into STEM challenge into their coursework. The professor team comprises professors from minority-serving institutions, HBCUs, and other colleges and universities. For the 2019–2020 competition, professors were invited to be a part of the team if they had expressed interested in the competition in one-on-one conversations and emails with competition management. Therefore, the first iteration of the professor team included more schools with a prior connection to national laboratories. The professor team comprised nine schools. The minority-serving institutions and HBCUs included Hampton University, North Carolina A&T University, Tennessee State University, Southern University and A&M College, and Clark Atlanta University. The other schools included Georgia Institute of Technology, University of Tennessee-Knoxville, Colorado School of Mines, and University of Alabama.

Competition management hosted monthly webinars for the professor team, during which the professors provided feedback on challenge ideas, evaluation criteria, competition timelines, and other competition details. These meetings commenced a few months prior to the start of the challenges. During these early meetings, professors suggested topic ideas for the challenges. After the JUMP into STEM team developed the challenges, the professors provided feedback and suggestions. The competition management finalized and selected the challenges based on the likelihood that the challenge would be included in the professors' courses.

Some professors offered the JUMP into STEM challenges to their students for a grade, such as in a capstone course. One school created a seminar course in order to offer it to their students separately. Some professors offered the competition as extra credit, but this method did not recruit as much participation. Overall, professors proved instrumental in encouraging student participation.

Many professors traveled with their students to the final competition event, providing the professors the opportunity to participate, engage with competition management, and meet other professors who also supported their students in the competition.

Outcomes

There have been two JUMP into STEM competitions: one spanning 2018–2019 and culminating in a final event at NREL on April 12, 2019, and one spanning 2019–2020 with a final event at ORNL on January 31, 2020. During the April 2019 final event at NREL, three students traveled to Colorado to present on behalf of their teams. The internship winners included two Georgia Institute of Technology economics majors and one University of Tennessee mechanical engineering major. NREL hosted two interns and ORNL hosted one during the summer of 2019. For the January 2020 competition, six teams (represented by 16 students) participated, representing Georgia Institute of Technology, Clark Atlanta University, Tennessee State University, Hampton University, and a combined team from University of California Berkeley, University of Michigan, and Carnegie Mellon University. The winners came from Georgia Institute of Technology (two public policy majors, one industrial engineering major, and one mechanical engineering major) and Clark Atlanta University (one computer science major and one industrial engineering major). NREL and ORNL are hosting three interns during the summer of 2020.

The three summer 2019 interns contributed to active research projects at NREL and ORNL. Below is a summary of the interns' work, quotes from their mentors, and their thoughts on the internship experience.

Sarah Tinsley, Summer 2019 JUMP into STEM intern at ORNL, Economics Major from Georgia Institute of Technology

Sarah worked under the mentorship of Dr. Piljae Im on a project titled, "Building Energy Modeling (BEM) for ORNL Buildings," which involved modeling real buildings in the area using EnergyPlus® and OpenStudio®. The project involved comparing the simulation outputs to the real energy data of those buildings and then calibrating the models to increase the accuracy, efficiency, and reliability of the models. After the calibration process, the models were used to apply and evaluate potential energy conservation measures. Throughout this project, Sarah assisted the team in creating new baselines for several machine shop space types, which the team included in a conference paper.

> "Sarah supported building energy modeling task for the ORNL campus. She has been involved in building auditing, developing an initial model using EnergyPlus, and calibrating the model with the measured data. Her contributions on this project helped us to finalize the model development and calibration, which will be further used for evaluating energy savings potential from various energy conservation measures."
> -Piljae Im, Ph.D., Research Scientist and mentor to Sarah Tinsley, September 16, 2019

> "My summer internship at Oak Ridge National Laboratory provided an opportunity to work alongside so many amazing researchers and fellow interns! I learned so much through the 'Building Energy Modeling (BEM) of ORNL Buildings' project...I want to again encourage any university student who is interested to compete in the JUMP into

STEM program challenges! You, too, could have the chance to work at ORNL for a summer!"
-Sarah Tinsley, Georgia Institute of Technology, August 31, 2019

Cade Lawson, Summer 2019 JUMP into STEM intern at NREL, Economics Major at Georgia Institute of Technology

At NREL, Cade worked on analysis software called ComStock™ that allows users to model the entire commercial building stock of the United States and apply different energy-reducing measures to gauge potential savings. Cade's role was to identify nonweather seasonal factors that impact energy use within commercial buildings and implement them within the model, generally by developing predictive models based on existing data related to factors such as tourism, hotel occupancy, and building-level electricity use, and then write OpenStudio measures to make necessary adjustments within the framework of ComStock.

"Cade identified several social economic factors impacting commercial building energy use. One significant factor is seasonal hotel occupancy, which Cade captured in an OpenStudio measure to use in ComStock, a representative model of the national building stock. This measure, along with other commercial building occupancy data that Cade collected, is vital in improving ComStock accuracy."
-Matthew Dahlhausen, Research Engineer and mentor to Cade Lawson, September 16, 2019

"JUMP into STEM was my first real opportunity to explore the crossroads of social science and data science through research on a meaningful and interesting topic. The project itself and my experience at NREL directed my interests toward the area of energy economics and analysis and shaped my career path and my passion in a way that I never saw coming just a year ago. I am so grateful to have learned from the expertise of everyone at NREL and ORNL, both during the Solar Decathlon Weekend and during my internship, and I can't wait to continue building my knowledge of energy issues and working towards a career in the same field!"
-Cade Lawson, Georgia Institute of Technology, September 21, 2019

Carl Woodard, Summer 2019 JUMP into STEM intern at NREL, Mechanical Engineering Major at University of Tennessee, Knoxville

Carl's work focused on thermal energy storage through the use of phase change materials. These phase change materials have specific melting/freezing points that allow them to take advantage of the sharp increase in heat capacity that occurs during melting/freezing. To make use of the phase change materials' advantages, the material is impregnated into a porous expanded graphite matrix that improves thermal conductivity. Carl's work on this project involved executing and improving test procedures used to quantify various properties of the expanded graphite/phase change material matrices and to optimize use of various additives for maximum performance.

"Carl was able to help improve the accuracy and precision of a custom experimental setup here that we use for characterizing phase change thermal energy storage materials

for building applications. This capability will support multiple NREL thermal energy storage projects moving forward."
-Wale Odukomaiya, Ph.D., Director's Fellow and mentor to Carl Woodard, September 16, 2019

"My experience with JUMP into STEM had an incredibly impactful effect on my career path. The competitive component alone pushed my ability and willingness to be creative in my engineering thinking and boosted my confidence in my own ideas. Because I was fortunate enough to be awarded an internship at the National Renewable Energy Laboratory, there is now less ambiguity in what a research career path actually looks like."
-Carl Woodard, University of Tennessee, Knoxville, September 25, 2019

All interns contributed to technical project work at the national laboratories. Their experiences gave them clarity on what a career at a national laboratory is like. Interns noted that both their internship and the JUMP into STEM final competition, which in 2019 was co-located with the Solar Decathlon Design Challenge Weekend, were important learning experiences.

Conclusion

JUMP into STEM provides students with learning experiences in building science innovation and research. Students who participate in the final competition event have an opportunity to present their innovations, learn from the presentations of others, and experience a national laboratory campus. Internship winners have the unique opportunity to gain valuable research and career development experiences. The interns also bring a unique perspective to their workplaces, from backgrounds and/or majors that are not yet well represented in the building science research community.

JUMP into STEM has grown significantly in the last two years. The number of submissions increased by threefold, and the number of student participants at the final competition increased from three teams (represented by three students) in 2019 to six teams (represented by 16 students) in 2020, showing that the competition is increasingly exposing more students to building science. The number of involved professors has also increased from approximately 5 in 2019 to 15 members in the 2020 professor team. The competition will continue to recruit additional professors to participate on the team in order to increase student participation.

Although still a new program, JUMP into STEM has been successful in addressing its goals of increasing energy efficiency equity (increasing contribution from underrepresented groups) and technological diversity (different majors). The competition design attracts diverse student teams, attributed to strategies such as evaluation criteria encouraging diversity and minority-serving institution/HBCU involvement on the professor team. The competition was integrated into at least seven courses during the Fall 2019 semester. The targeted recruitment of professors led to the engaged involvement of four minority-serving institutions, including Clark Atlanta University, Hampton University, North Carolina A&T University, and Tennessee State University. The competition encourages students from different backgrounds and majors underrepresented in the building sciences to participate, and many were awarded internships. These nontypical majors include economics, industrial engineering, computer science, and public policy. Student teams comprised an interdisciplinary mix of majors, such as merging computer

science with public policy, so participants get exposed to working with others with different knowledge bases, training, and experiences. Integrating interns from nonengineering majors into building science research teams at national laboratories is helpful to the teams, because the students bring a unique perspective to the research.

JUMP into STEM challenges college and university students to tackle real-world building science problems. If impacts are consistent with Clarke et al. (2019) and Ozogul et al. (2019), then the exposure building science is likely to pique students' interest in the field and encourage self-efficacy in this STEM subject, potentially leading to more students entering buildings science careers. The mentorship provided to JUMP into STEM winners will provide students the sense of belonging in the field (Dennehy and Dasgupta 2017; Ceglie 2020; Byars-Winston et al. 2011), potentially leading to their retention. In the future, JUMP into STEM (and similar programs) should continue to work to foster a sense of belonging among underrepresented groups to increase the likelihood that these students will move into building science careers. This can be done through opportunities for students to receive mentorship from professionals who are from underrepresented groups (including women), more exposure to research and careers in the building sciences, career counseling, and also welcoming building science clubs and organizations that embrace diversity.

JUMP into STEM is evolving; with each competition, there are new best practices established and lessons learned that lead to improvements. This paper summarized best practices such as the advisory board, professor team, recruitment practices, and intentional development of the challenges developed for the first two competitions. The competition management team is finding solutions for overcoming other known challenges, such as making the final competition more accessible to students. For both 2019 and 2020, JUMP into STEM provided food and housing for final competition attendees, and students provided their own transportation to the competition location (or professors drove a vehicle with the students to the event). The cost of the transportation, such as an airline ticket, prevented some attendees from participating. For the 2021 competition, JUMP into STEM will provide transportation to the final event for students competitors and their faculty mentor, which will make participation more accessible.

As JUMP into STEM grows, it will continue to attract participants from diverse backgrounds. As these students gain experience through participating in the competition and potentially working as an intern at national laboratories, they build important building science and career development skills. These skills could help them find jobs and hopefully increase their likelihood that they will pursue careers in energy efficiency. As more college-educated individuals enter this field, it becomes more likely that they will move into impactful decision-making and leadership positions in energy efficiency, bringing a diverse perspective to key decisions affecting energy in their city, region, or on the behalf of the United States.

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Appendix A: Evaluation Criteria for the Online Competition

Technical (45%)

- Impact to reduce energy consumption in buildings
- Ability to maximize occupant comfort and/or indoor air quality
- Technical potential and merit
- Response meets all technical requests of the challenge.

Innovation (35%)

- Market characterization and readiness for proposed idea
- Replicability and scalability
- Is the idea unique and/or innovative?

Diversity of thought (20%)

- Multidisciplinary team approach (meets requirement for two or more majors on a team). Teams should comment on their majors in their project team statement.
- Gender balance: More points will be awarded to teams that attain even male/female split.
- Based on the idea submitted, do the students bring a unique perspective to the problem?
    - This includes whether the report presents students' perspective on how their solution will address a need for a society or a subset of society, such as a marginalized population. Do the students understand these stakeholders' needs?
    - This also includes whether the team members bring diverse perspectives to the problem, as identified in the project team statement.

Appendix B: Evaluation Criteria for the Final Competition

Technical (30%)

- Impact to reduce energy consumption in buildings
- Technical potential and merit
- Technical response.

Innovation (25%)

- Market characterization and readiness for proposed idea
- Replicability and scalability
- Innovation—originality and creativity.

Diversity and Applicability (20%)

- Multidisciplinary team approach
- Students bring a unique solution to the problem by addressing a particular set of stakeholders
- Applicability to stakeholders.

Presentation (25%)

- Effective delivery of ideas
- Presentation preparation.

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