Clean Energy Program Task Force Report

July 2014

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Executive Summary

Background

In 2013, the Maryland General Assembly enacted and Governor O'Malley signed into law the Maryland Offshore Wind Energy Act of 2013 (Chapter 3, Md. Laws, 2013). Under the Act, a Clean Energy Program Task Force ("Program Task Force") was established to consider new opportunities for Maryland's Historically Black Colleges and Universities (HBCUs) from offshore wind. Its legislative mandate was to study the feasibility of establishing a terminal degree or certificate program in clean energy at one or more of the following colleges and universities:

- Bowie State University (BSU);
- Coppin State University (CSU);
- Morgan State University (MSU); and
- University of Maryland Eastern Shore (UMES).

In October 2013, the Program Task Force convened the first of seven meetings held between October 2013 and July 2014. During this time, Program Task Force members thoroughly researched and discussed clean energy technologies and clean energy policies in Maryland. In addition, Program Task Force members assessed the academic strengths of Maryland's HBCUs to determine the feasibility of developing terminal degree and certificate programs in clean energy at each institution. Based upon this analysis, the group determined where clean energy programs could be developed, taking note of barriers to such development throughout the process. The Program Task Force then generated the following recommendations in accordance with its mandate from the Maryland Offshore Wind Energy Act of 2013. The recommendations will be further explained in the body of the report.

List of Recommendations

- Addition of two faculty budget lines at Bowie State University to create Ph.D. programs in clean energy solutions and the environment; one replacement faculty, and one in aerospace engineering to complement current faculty expertise.
- Addition of two faculty budget lines at Coppin State University to establish two Master's degree programs in clean energy with concentrations in solar and wind energy to serve as "feeder" programs to new Ph.D. programs at other institutions;
- Addition of two faculty budget lines at Morgan State University to create a Ph.D. program in distribution/urban clean energy adaptability to the built environment, and sustainable environmental/energy conservation engineering, including basic and applied research;
- Addition of two faculty budget lines at the University of Maryland Eastern Shore to create Ph.D. programs in rural clean energy generation, energy issues, and wind, including basic and applied research;
- Build relationships with the clean energy industry and existing conventional energy providers. Investigate opportunities to collaborate with private industry and minority business enterprises to leverage federal and other grant funds; and
- Designate a portion of the funds in the Maryland E-Nnovation Fund towards building capacity in the area of energy and sciences (environmental, materials engineering, etc.) for Maryland's HBCUs.

Program Task Force

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Program Task Force Purpose

The legislative mandate of the Program Task Force is to study and make recommendations about the feasibility of establishing a terminal degree or certificate program in clean energy at one or more of the following colleges and universities:

(1) Bowie State University;
(2) Coppin State University;
(3) Morgan State University; and
(4) University of Maryland Eastern Shore.

These recommendations are respectfully submitted in accordance with § 2-1246 of the State Government Article, which requires the Clean Energy Program Task Force to submit a report on its findings and recommendations to the Governor and the General Assembly on or before July 31, 2014.

Introduction

Background

In May 2004, the State of Maryland demonstrated its commitment to support renewable energy by adopting its Renewable Portfolio Standard (RPS). The RPS, as it was originally adopted, required Maryland electricity suppliers to obtain 10% of their electricity from renewable resources. However, in 2008, through the leadership of the O'Malley-Brown Administration and the Maryland General Assembly, Maryland doubled its RPS requirements. As seen in Figure 1, this bold modification to the RPS now requires, that by 2022, 20% of Maryland's electricity needs be met by renewable resources by 2022.

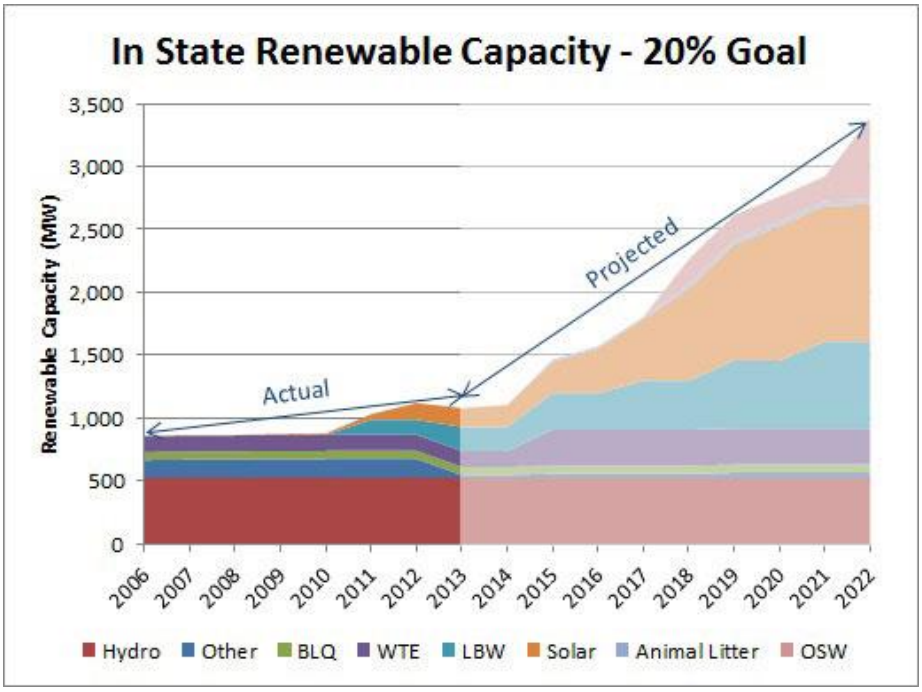

Fig. 1 In-State Renewable Capacity (Actual and Projected)

As a result of the RPS' adoption, Maryland saw exponential growth in the installation of solar and land-based (terrestrial) wind. In addition, the RPS was modified to include waste-to-energy and thermal technologies, such as solar water heating and geothermal heat pumps. Despite the notable growth in the State's renewable generation capacity, which has seen an 8.2%[1] increase since 2007, Maryland was still projected to fall short of its 2022 goal. In order to meet this goal, the O'Malley-Brown Administration recognized that yet another source of renewable energy generation would need to be developed. Therefore, in 2009, the O'Malley-Brown Administration asked the Maryland Energy Administration to form a State/Federal Task Force to explore developing an offshore wind farm off the coast of Maryland.

Since that time, numerous stakeholders collaborated to strategize on offshore wind development in Maryland. The Maryland Energy Administration worked closely with the General Assembly, the Public Service Commission, the U.S. Department of Energy, and the U.S. Bureau of Ocean Energy Management to navigate the legal and regulatory path toward deploying offshore wind farms. Throughout this process, the MEA also involved stakeholders such as wind developers, the shipping and fishing industry, the hospitality sector, individual towns and cities, local businesses, educational institutions and the

[1] As of 2013; source: https://data.maryland.gov/goals/renewable-energy

national and international business community. In May 2013, as a result of much work and great cooperation among all of these stakeholders, the General Assembly passed the Maryland Offshore Wind Energy Act of 2013.

The General Assembly recognized that beyond meeting the requirements of the RPS and providing Marylanders with cleaner and healthier air, the Maryland Offshore Wind Energy Act was also an opportunity to develop Maryland's entire clean energy business sector. Under the new law, a Clean Energy Program Task Force was tasked to study the feasibility of creating clean energy certificate and terminal degree programs at HBCUs in Maryland.

Opportunities for HBCUs

Although the role of clean energy in addressing climate change, the need for cost effective energy in the new century, and the limits of current energy sources have been elevated in recent years, limited opportunities exist for graduate and terminal degree program enrolment in the United States. In 2013, as the Massachusetts Institute of Technology prepared for a nationwide conference on clean energy, it contacted more than one hundred colleges and universities to catalog terminal (Ph.D.) programs in clean energy to invite those programs to lead the conference. It found none.

When the Program Task Force weighed the value of creating Maryland terminal degrees in clean energy, it concluded that although terminal degree programs are expensive, they attract industry, talent, and capital. The European Clean Energy market proves that when industry, academia, and government collaborate, innovation moves the economy forward. Although Maryland institutions rank third in receipt of research dollars nationwide, Maryland is only ranked 37th, nationally, in commercializing the research into industrial talent and jobs. Based on Maryland's HBCUs successes in the clean energy research and degree markets thus far, they are uniquely poised graduate clean energy Ph.D.s in the State and Nation. Morgan State University is 7th in the Nation in the production of African-American Engineering Ph.Ds., and it produces half of the State's African-American engineers at the Bachelor's degree level. Morgan is recognized as a pioneer in energy distribution systems.[2] Coppin State University has been generating research in solar engineering since 2007. UMES has been investing its rural assets in solar and wind installations and research since 2008. UMES contributed academic

[2] "Top 100 Producers of Minority Degrees 2013, Diverse Issues in Higher Education

research to Maryland's off shore wind marine life issues, setting Maryland on its way to lead in the new industry. Bowie State has invested in sustainability initiatives for a number of years and has an active research grant focused on developing a new type of highly efficient wind turbine that is responsive to low winds of any direction.

As Maryland moves toward a more diverse energy mix, away from traditional fossil fuel sources, the need for increasing basic and applied research is increasing. As the State's energy and environmental progress continues, it can leverage the growing clean energy industry to develop terminal degree and certificate programs at Maryland HBCUs. Further, as Maryland pioneers the nation's offshore wind efforts with the promise of a utility scale offshore wind deployment ten miles east of Ocean City, its HBCUs, with state support, can provide needed basic and applied research, as well as, graduate the trained personnel necessary for new start-ups and to expand the clean energy industry in the State. Furthermore, the transformation Maryland is undergoing presents a new opportunity for HBCUs to extend specialized research efforts, thereby contributing toward global renewable energy solutions while also attracting the clean energy industry to the State.

Lastly, with broader involvement in the clean energy technology spectrum, HBCUs will capture additional external funding, for example, from federal programs such as the "HBCU Program" at the National Energy Technology Laboratory (NETL), and the Minorities in Energy Initiative (MIE) sponsored by the US Department of Energy.[3] The NETL program provides generates cooperative research among HBCU institutions, the private sector, and federal agencies. NETL's central thrust is to generate fresh ideas, tap unique talent, define applicable fundamental scientific principles, and develop advanced concepts for generating new and improved technologies across the full spectrum of all energy research and development programs.

In response to the Program Task Force's mandate, Maryland's HBCUs are, indeed, well equipped to develop and implement new clean energy Ph.D. programs, feeder Master of Science programs, and certificate programs. To achieve Maryland's vision of engaging HBCUs and using them to attract and support growing industries, the Program Task Force presents the following tables regarding existing and needed capacity to create new terminal degree programs and submits recommendations for the

[3] http://www.energy.gov/diversity/services/minorities-energy-initiative

Governor and the General Assembly. Recommendations summarized below are explained in detail in the Recommendations section.

Current Capacity to Support Ph.D. and Certificate Programs in Clean Energy at HBCU

The Program Task Force was charged with assessing the capacity of each HBCU to establish terminal degree or certificate programs in clean energy. The Program Task Force defined a terminal degree as a Ph.D. that results from independent, reproducible research that adds new knowledge or leads to new discoveries. The Program Task Force defined a certificate program as a specialized short-term program (less than two-years) that recognizes and certifies competency in a specified occupation field. It may complement an existing undergraduate or graduate degree. The Program Task Force also determined that feeder Master of Science degree programs were necessary to feed qualified students into Ph.D. programs.

Members determined that investing in Ph.D. programs rather than certificate programs added more value to the State by enabling the HBCUs to produce basic and applied research, as well as the researchers and advanced degree workers needed to further the State's progress toward the RPS goal.[4] Specifically, these new Ph.D. programs will fuel economic development, knowledge acquisition, job growth, research innovation, and HBCU enhancement in ways that post-undergraduate or graduate certificates cannot. In addition, these pioneering doctoral programs will bring national recognition and prestige to both the State and the institutions. Further, establishing clean energy doctoral programs at HBCUs furthers the State's long-term executive and legislative goals to enhance the capacity of HBCUs, including adding high demand programs to their program inventory. It also supports the goals of the Maryland State Plan for Postsecondary Education 2013-2017. http://www.mhec.state.md.us/higherEd/2004Plan/2013%20Maryland%20State%20Plan/MHECStatePlan_2014.pdf.

While the Program Task Force recommendations capitalize on the need for improved communications between HBCUs and the clean energy industry, they create opportunities for both sides. Maryland has an ever growing clean energy work force and is establishing itself as a clean energy hub on the east

[4] *See* COMAR 13.B02.03B(3) and (5) for definitions of certificate and doctorate; *see* COMAR 13B.02.03.25 for additional information on certificate programs.

coast. The alignment of HBCU research goals with the needs of industry could significantly contribute to the State's goal of becoming a hot spot for clean energy investment. Moreover, strong relationships between HBCUs and industry, and even joint research efforts with industry, could help bring in much needed Federal research funding to State.

Bowie State University: Clean Energy Degree Program Capacity

Founded in 1865, Bowie State is the oldest Historically Black College/University in Maryland and one of the ten oldest in the country. It is also a diverse university whose more than 5,400 students, along with faculty and staff, represent many ethnic and cultural backgrounds.

Bowie State University provides high-quality and affordable educational opportunities for students with ambitions to achieve and succeed. In addition to its 23 undergraduate majors, Bowie State offers 35 masters, doctoral and advanced certification programs with specific focus on science, technology, business, education and related disciplines.

Bowie State is in the midst of one of the nation's most exciting metropolitan areas, within easy reach of Washington, DC, and Baltimore. At the same time, it boasts a serene campus on a 300-acre suburban wooded tract (BSU website).

Bowie State became one of only six national Model Institutions for Excellence in science, engineering and mathematics as a result of an 11-year $27 million grant award from the National Aeronautics and Space Administration/National Science Foundation. This award significantly strengthened the institution's academic infrastructure and enhanced an already excellent computer science and technology program that has consistently ranked first in the nation in graduating African American students with master's degrees.

Bowie State University, throughout its history, has achieved major milestones in spite of limited resources. In spring 2005, with the unveiling of the supercomputer built by its faculty and students, Bowie State emerged as a leader among higher education institutions in computing power. At the time of its unveiling, Bowie State's supercomputer, Xseed, was the fastest supercomputer at any higher education institution in the state of Maryland, the eighth fastest in the United States, and among the top 200 fastest in the world (BSU Catalog).

CURRENT CARNEGIE CLASSIFICATION

DRU: Doctoral/Research Universities

SUSTAINABILITY INITIATIVES and RENEWABLE ENERGY

In 2006, the University President (Dr. Mickey L. Burnim) signed the American College and University Presidents' Climate Commitment (ACUPCC). Within the first year of ratification of the agreement, the Climate Commitment Coordinating Committee (C4) was established to initiate the development of a comprehensive plan to achieve climate neutrality on campus. The C4 is committed to enhancing sustainability awareness as a way of life for all campus members. The C4 consists of student representatives, faculty, staff, and community partners who meet monthly throughout the academic year to plan green activities geared toward increasing education and awareness on sustainability initiatives for the campus community.

As a result of this initiative, a Carbon Footprint Inventory of the campus was completed to help BSU gauge the amount of carbon emission it produces. This yearly inventory is used to assist in alleviating carbon emissions throughout campus. Another major accomplishment is the achievement of LEED (Leadership in Energy and Environmental Design) Gold Certification in spring 2014 on its Student Union, the first campus building to receive such certification and the first Student Union with such certification among all HBCUs.

Additionally, the Bowie State University campus community and visitors now have a convenient, more energy efficient way to power up their mobile devices with the installation of two solar-powered charging stations in May 2014. The first-of-its-kind charging stations provide a lighted, covered outdoor table and seating for up to eight people, plus two wheelchairs, where you can recharge your mobile phone, laptop and tablet, camera, and more, while using clean sustainable energy. Each station is equipped with six power outlets and four USB outlets, with an automatic shut-off system during unsafe, rainy conditions (BSU Website).

CLEAN ENERGY AND ENVIRONMENTAL RESEARCH

Faculty members within the Department of Natural Sciences have published numerous refereed publications in environment-related research. Faculty disciplines within the Department of Natural

Sciences include biology, chemistry, physics, bioinformatics and engineering. Within the department, 100% of the tenured/tenure-track and contractual faculty possess Ph.D. degrees.

One of the physics/engineering faculty recently obtained MHEC funding to conduct research in analysis, modeling and optimization to support improved turbine blade performance through selection of materials and optimizing design of remaining turbine components.

Last year (2013), the University embarked upon climate studies. A faculty member from Natural Sciences developed a course by that same name, with support from the American Meteorological Society. Over the years, BSU's STEM faculty have been involved in energy-related research, such as that performed by participants of the Chesapeake Information Based Aeronautics Consortium (CIBAC) housed at Morgan State. CIBAC conducts research in the areas of aeronautics and aviation and is dedicated to the promotion and advancement of aerospace sciences and engineering. Ten BSU faculty members have participated in the research of this consortium.

BSU's Proposed Ph.D. Program in Clean Energy and Environment

In January 2014, a preliminary proposal for a Ph.D. program in Clean Energy and Environment was submitted to the BSU administration. Because energy is inextricably linked to the environment, the degree would focus on energy and the environment.

Program Rationale: This country has high dependence on fossil fuels. Fossil fuels are derived from natural organic sources that are non-renewable and they emit carbon into the atmosphere, when burned. The nation is seeking alternative energy sources to minimize the use of fossil fuels. To maximize the potential for discovering new energy sources, extensive research is needed. Higher education institutions have contributed greatly to important discoveries in this country. Independent research in university laboratories has been the mainstay of these discoveries.

Bowie State assessed its resources and has determined that with the expertise of its STEM faculty, and with a new state-of-the-art science facility designed to produce its own electricity that will feature a green roof and dedicated faculty research space coming on line in 2017, Bowie State University can be

competitive in offering a Ph.D. degree in clean energy and environment. It has been determined that two new faculty lines will be needed.

Coppin State University: Clean Energy Degree Program Capacity

Coppin State University prepares students to meet the challenges associated with urban communities through its major academic programs in Education, Health Care, and Science, Technology, Engineering & Mathematics (STEM) disciplines. Its target population includes graduates of Baltimore City and Baltimore County Public School Systems. As a Carnegie master's comprehensive (MA I) institution, it provides graduate level programs and approval is pending for reclassification to a Comprehensive Doctoral Institution. Building on the current Carnegie classification of a master's comprehensive institution and looking towards the future, the university has obtained preliminary approval to offer its first Doctor of Nurse Practice (DNP), which will address the shortage of doctoral trained nursing professionals to fill university teaching and clinical positions.

Additional priorities include an emphasis on community engagement and sustainability. The University, through its strategic plan, is building a culture of community engagement by developing strategic partnerships with the local community. The campus sustainability efforts are aligned with the University System of Maryland's 2020 Strategic Plan and the federal government's efforts to reduce the carbon footprint and enhance campus stewardship on environmental issues. In March 2008, Coppin State University signed the American College and University Presidents' Climate Commitment (ACUPCC), a coalition of over 670 colleges and universities concerned about the impacts of global warming and dedicated to reducing campus greenhouse gas emissions. This agreement has provided an excellent opportunity to inform the University and the surrounding community about the impact of global climate change and has increased awareness of climate change issues. Coppin introduced a comprehensive climate action plan containing policies and practices designed to reduce the university's greenhouse gas emissions and make sustainability and environmental justice a key part of the curriculum. Coppin also simulated the most efficient solar energy cells in the world and worked with 200 university and high school students to explore the properties of solar cells and investigate how nanomaterials are used to increase solar conversion efficiency.

Over the last 10 years, Coppin has been consciously engaged in environmentally conscious practices, including installing new energy efficient heating and cooling systems; energy efficient light fixtures, motion sensor lighting systems; and installing 'green tile' which contains natural rock and recycled glass. Coppin follows Maryland state guidelines that all new campus buildings must meet or exceed LEED-Silver green building specifications. The Physical Education Complex, which was completed in 2010, is Coppin State's first LEED-certified building. The Science and Technology Center, which is currently under construction, is aiming for LEED Gold. CSU renovated the central quad by replacing the brick and concrete with drought-tolerant plants, which will allow for better storm water management. The university installed a 500-kilowatt photovoltaic system which covers three to five percent of its energy needs. Coppin State University also worked with HP engineers to design a computer that is Energy Star compliant and energy-efficient. The new units save CSU $40 per computer per year in power consumption, with a total savings of about $45,000 per year.

Further, Coppin established a Center for Sustainability and Environmental Justice (CSEJ) to promote environmental education and research. It also made the commitment to environmental stewardship a key element within the university's 2009 to 2019 Facilities Master Plan.

Clean Energy Research

Coppin State University is undertaking a comprehensive expansion of its academic programs and facilities. In a year (May 2015), a new state-of-art Science and Technology center will be completed. This new center will bring a unique opportunity not only to strengthen the existing programs but also launch new ones. The Department of Natural Sciences houses the center for Nanotechnology, which undertakes advanced research that focuses on the design and simulation of multi-junction photovoltaic cells for solar energy. At the moment this center is positioning itself to patent the highest efficiency its researchers obtained through simulation studies. There are 9 faculty members that are actively engaged in the day-to day activities of the center.

The Center enjoys financial support from the Constellation Energy, Technology Development Corporation (TEDCO), DOE, NASA and Undergraduate Education and Research Traineeship (NSF-IGERT) program. Over years, the center has been building capacity and by fall 2015 will be launching a new degree program in "Materials Physics and Nano Science" Some of the ongoing research projects include

Dye-sensitized Solar Cell: Harnessing Energy from Natural Dyes like Fruits and Vegetables, Design by Simulation of A High-Efficiency Multi-Junction Solar Cell, Energy Storage and Rapid Charge System Using Electric Double Layer Capacitor for the Solar Light Rail and Exploring New Generation of Quantum Dot (Q.D) Nano Solar Cell. Many of these research projects provide internship opportunities for undergraduate and graduate students. Moreover, high school students also take part in these research programs so that they are nurtured into STEM programs.

Research, Grants and Collaborations related to Clean Energy and Sustainability

Jamal Uddin, Ph.D.

- Energy to Educate (E2) grant 2012 collaboration with Coppin Academy high school (50K)
- Energy to Educate (E2) grant 2013 Collaboration with BDJ high school and BITH-energy company, Baltimore (50K)
- Energy to Educate (E2) grant 2014 Collaboration Coppin Academy, Baltimore (50K), submitted 10/1/13
- Wilson H. Elkins Professorship STEM grant 2012-13 (65K)
- Wilson H. Elkins Professorship STEM grant 2013-14 (40K)
- NASA ESMD Senior Design Project, 2012-13 (4K)
- Collaboration on Nanotechnology research with the Indian Institute of Technology (IIT) and Dhaka University, 2013
- Collaboration on solar light rail research with Tokyo Institute of Technology and Tama University, Japan, 2013-2015
- Collaboration on Hybrid and multi-junction solar cell research with Kookmin University, Korea, 2014-2016

Mintesinot Jiru, Ph.D.

- The Socio-environmental Synthesis (SES) approach: solving complex environmental and ecological problems (SESYNC-2012 NSF-Grant # DBI-1052875)
- Introducing Climate Sciences at Minority serving Institutes supported by the American Meteorological Society (AMS)

- Ecological Society of America (ESA) – Introducing the "SEEDS" Chapter at Coppin State University, Co-chair
- Water quality deterioration of the liberty reservoir: causes and impacts (SESYNC supported)

Other faculty involved in Energy and sustainability research include: Gilbert Ogonji, Ph.D. (Professor of Biology), Ronnie Boyd, Ph.D. (Professor of Biology), Fred Nesbitt, Ph.D. (Professor of Chemistry). Tatiana Roth, Ph.D. (Assistant Professor of Biology), Jacob Adeyeye, Ph.D. (Associate Professor of Biology), Hany Sobhi, Ph.D. (Associate professor of Chemistry) and Robert Javonillo, Ph.D. (Assistant professor of Biology) .

Coppin plans to build the new M.S. programs in clean energy from the existing undergraduate science programs. The new clean energy program will have two concentrations:

(1) Wind energy - As the global wind industry grows, so will the need for professionals with specialized training in wind energy, who understand the mechanisms of wind turbines, can model wind farm performance, and perceive the complexities of siting, permitting, and logistics. These project leaders should also be able to provide real-world context to their co-workers and help maintain a company-wide focus on the sustainable enterprise with a focus on wind and solar energy. This specialization will serve as a feeder program for the Ph.D. programs in sister institutions.
(2) Solar Energy - with an ever-growing "green economy," the need is increasing for professionals who understand resource assessment, project development, system design, and emerging technologies for both solar thermal and solar electric systems. This specialization will produce the needed workforce in this area.

Current Capacity for Clean Energy Degree Production at Morgan State University (MSU)

As one of the fifteen HBCUs, and one of two HBCUs in Maryland that has school of engineering accredited by the Accreditation Board for Engineering & Technology (ABET). Morgan State University possesses faculty and research facilities poised to participate in Maryland's emerging clean energy sector. Offering degrees in the electrical, civil, and industrial engineering, Morgan ranks high across the

Nation in the production of African-American engineers. MSU's research faculty has expertise in power distribution, circuit design, dynamics and control of energetic systems; active distributed controls of offshore wind energy, building energy and building environmental systems, passive and active solar heating and cooling systems, and cyber security, which is important to protect urban electrical infrastructure.

Relevant undergraduate curriculum consists of four courses (Power Electronics, Power Systems, Renewable Energy Technology, and Electric Drives/Machines). As for the relevant graduate curriculum, it consists of advanced versions of the undergraduate courses with two additional courses, Smart Grid and Modeling/Control for Power Electronics. (Graduation Metric: Eight undergraduate students were accepted to Ph.D. power programs at other institutions, and 80% of MSU's power capstone students are employed by energy related companies.) In addition, the School of Engineering collaborates with MSU's School of Architecture and Planning in MSU's new *Center for the Built Environment & Infrastructure Studies* (CEBEIS) building, which focuses on urban sustainability and the design and retrofit of urban structures. Programs targeted towards clean energy systems that have to consider transmission, distribution, and renovation have great promise to tap the synergy these two schools provide. The CEBEIS building also contains a seismic simulator, that includes 3m x 3m platform with a 10,000 kg specimen maximum mass capacity, 10-20-6 inches x-y-z working displacement range, and 0-60 Hz operating frequency simulating earthquakes upwards to 7.0 on the Richter scale. This capability is important for design and testing of materials and structures used in the urban energy network.
Finally, MSU has two major initiatives focusing on renewable energy:

Center for Advanced Energy Systems and Environmental Control Technologies (CAESECT)

The Center for Advanced Energy Systems and Environmental Control Technologies (CAESECT) will develop fundamental and applied technology to improve energy efficiency, production, utilization across a wide range of industries. In education, it will impart a cross-disciplinary approach to students at all levels. In industrial collaboration, it will work with member companies to develop new methods for alternative renewable energy utilization, advanced energy systems design and environmental control technologies.

Patuxent Environmental & Aquatic Research Laboratory (PEARL)

Morgan State University's Patuxent Environmental and Aquatic Research Laboratory (PEARL) is a 22,000 square foot laboratory and office building located near the Patuxent River (part of Chesapeake Bay watershed) in Saint Leonard, Maryland. Research conducted at the facility is designed to increase the understanding of coastal ecosystems, so that these systems may be properly managed and protected. Personnel at PEARL have over 40 years of experience in research on fishery resources and working with the energy industry to monitor discharges from power plants, and their effect on the aquamarine population in the Bay. Dr. Mark M. Bundy, Director of Environmental Programs at the PEARL, has recently been awarded $184,947 for the project titled, "*Economic Impact of the Proposed Wind Turbines on Offshore Marine Recreational Fishing Industry Study"*. The goal of the project is to develop a bio-economic model for assessing the impact of wind farms on the local recreational fishing industry.

The Maryland Offshore Wind Energy Act of 2013 allows for the development of a wind turbine farm between 10 and 30 miles off the Maryland coast. While the exact location of the turbines has yet to be determined, this is an area frequented by recreational anglers. Wind turbines and other structures in open water are often considered to have a positive impact on fishery populations by providing such benefits as a surface for food sources to grow on and refuge from larger predators. Working with other researchers, Dr. Bundy will conduct a two-year study to estimate the potential impacts of wind turbines on Ocean City's recreational fishery. They will then use these estimates to assess the economic impact on the local economy. This approach has the potential to be used as a model for other jurisdictions to evaluate the economic impact of installing wind turbines.

Curriculum Capability:

Energy Efficiency Buildings

(1) Energy Auditing (Hancock)
(2) Building Controls (Lonworks)
(3) Building Energy Modeling (Using HEED, Energy Plus, Green Studio)
(4) Benchmarking (Energy Manager Portfolio)

Renewable Technology

(1) Commercial Integration
(2) Solar /Wind Farms Design
(3) Efficient Solar Panel Development

(4) Stirling Engine Development

(5) Smart Grid (Transmission/Distribution)

(6) Electric Vehicles/Two Way Converter

(7) Demand Response (Using Lonworks)

(8) Data Management (Visual Analytics)

(9) Utility Preparedness Tools

Efficient Lighting

(1) Simulation Design/Integration (Using Dialux)

(2) LED Drive Development Distributed Energy

(3) Hybrid Inverter

(4) Micro-Grid Design

Education/Training

(1) BPI Certification

(2) Efficient Lighting

(3) K-12 Energy STEM

(4) Renewable Technologies

Current Capacity for Clean Energy Degree Production at the University of Maryland Eastern Shore

The University of Maryland Eastern Shore is currently one of 15 HBCUs in the nation to have an ABET accredited engineering program. UMES is primed for the expansion of programs to support the training of a future workforce prepared for the development of wind energy and other sustainable resources on Delmarva, across the Maryland, and around the world. In 2009, with the support of our non-profit affiliate Maryland Hawk Corporation, UMES installed a two megawatt (MW) solar photovoltaic power system that is currently supplying electricity for the university campus. Our plan is to expand the reliance on clean energy by installing a 2 to 3 MW wind turbine this year and in the future to add other renewable energy systems.

Academic programs on renewable energy are also being expanded. In July 2011, UMES contracted with Princeton Energy Resources International (PERI) to participate on a Workforce Development Program sponsored by the U.S. Department of Energy (DOE). The purpose of this program is to provide training

on renewable energy technology and business for the rural electric power industry. Participants may include UMES students pursuing business and engineering degrees as well as continuing education for wind and solar equipment suppliers/installers, local farmers, business owners, community planners, and electric power company staff. Part of this training is planned to include technical and economic analysis of wind resource measurements in the unique wind regime on Delmarva. Measurements collected on the proposed tower will be analyzed under the DOE program and results will be available to UMES students, other Maryland schools, businesses and to the general public.

UMES is also supporting the Maryland offshore wind energy program. Students in the engineering program will be assisting in the bathometric, meteorological, hydrologic and subaqueous geotechnical data collection in the Maryland offshore wind energy lease block.

There are seven full-time faculty qualified to teach Renewable Energy Systems Engineering courses in the Electrical and Mechanical Engineering area. These faculty are listed below:

Dr. Alvernon Walker is the Chair of the Engineering and Aviation Sciences Department and an Associate Professor. He received his Ph.D. in Electrical Engineering from North Carolina State University and a M.S. and B.S. in Electrical Engineering from North Carolina A&T State University. He has authored and co-authored several scholarly journal articles in national and international journals. He has taught Power Electronics, Analog and Digital Electronics, Digital Logic, Digital System Design and Mixed-Signal System Design.

Dr. Ibibia.K. Dabipi is a Professor in the Engineering and Aviation Sciences department. He received his Ph.D. and M.S. in Electrical Engineering from Louisiana State University and a B.S. in Physics/Mathematics from Texas A&I University. His experiences include working at Bell Communications Research and AT&T Bell Labs as a member of technical staff during the summers of 1984 through 1987. He has authored or co-authored many technical articles for publications and presentations.

Dr. Yuanwei Jin is an Associate Professor in the department of Engineering and Aviation sciences.

Dr. Payam Matin is an Associate Professor in the department of Engineering and Aviation Sciences.

Dr. Abhijit Nagchaudhuri is a Professor in the Engineering and Aviation Sciences department.

Dr. Rajnish Sharma is an Assistant Professor in the Engineering and Aviation Sciences department.

Dr. Lei Zhang is an Assistant Professor in the department of Engineering and Aviation Sciences.

The faculty with Electrical or Computer Engineering background (i.e. Drs. Walker, Jin, Dabipi and Zhang) can cover the following courses in the Renewable Energy Systems Engineering courses: ENGE 607 Power Electronics, ENGE 609 Energy Systems and Conversion, ENGE 610 Wind and Hydroelectric Power, ENGE 696 Master Project, ENGE 697 Master Thesis and ENGE 699 Master Thesis or Project Continuation. The faculty with degrees in Mechanical or Aerospace Engineering (i.e. Drs. Matin, Nagchaudhuri and Sharma) can teach the following courses: ENGE 608 Heat and Mass Transfer, ENGE 610 Wind and Hydroelectric Power, ENGE 696 Master Project, ENGE 697 Master Thesis and ENGE 699 Master Thesis or Project Continuation. The Engineering and Aviation Sciences department needs new faculty to cover the following courses: ENGE 603 Introduction to Systems Engineering, ENGE 604 System Conceptual Design, Design and Integration, and Test and Evaluation and ENGE 606 Electrochemistry for Renewable Energy. Five full-time faculty in the Business, Management and Accounting department are qualified to teach FINA 632 Global Finance, Management and Strategic Finance for the Earth, Energy, and Materials Industries. Although the current Engineering faculty can cover many of the new program courses additional Electrical and Mechanical Engineering faculty are needed because the current faculty are fully loaded with the courses in the Bachelor of Science Engineering program. The Engineering and Aviation Sciences department will need two additional faculty in the following areas:

- 1 Electrical Engineering faculty
- 1 Mechanical Engineering faculty

Recommendations

Based on the demonstrated capacities described above, all four HBCUs are poised to develop clean energy Ph.D. and certificate programs. The Program Task Force recommends the development of the following programs:

- **Addition of two faculty budget lines at Bowie State University for Ph.D. programs in clean energy solutions and the environment**

- **Addition of two faculty budget lines at Coppin State University to focus on feeder Master's degree programs in clean energy with concentrations in solar and wind energy**

- **Addition of two faculty budget lines at Morgan State University to create a Ph.D. program in distribution/urban clean energy adaptability to the built environment, and sustainable environmental/energy conservation engineering, including an emphasis on both basic and applied research**

- **Addition of two faculty budget lines at the University of Maryland Eastern Shore to create Ph.D. programs in generation, rural clean energy issues, and wind with applied research integral to the program**

- **Build Relationships with the clean energy industry, and existing conventional energy providers. Investigate opportunities to collaborate with private industry and minority business enterprises to leverage federal and other grant funds.**

- **Designate a portion of the funds in the Maryland E-Nnovation Fund towards building capacity in the area of energy and sciences (environmental, materials engineering, etc.) for Maryland's HBCUs.**

Additional Resource Needs

In order to develop new Ph.D. programs at Maryland's HBCUs and address the recommendations of the Clean Energy Program Task Force, initial financial support is required. The development of a single program at any institutions will require approximately $1,117,500 per new faculty member over a four-year start-up period as illustrated in Table 1. Note that the faculty member salary and graduate student assistantship costs decline after year two, which assumes successful obtainment of external research funding (federal or other grants). In addition, an academic program research start-up package and funds for marketing and recruitment are required.

Table 1: Estimated Additional Resources to Create Clean Energy Graduate Programs at Maryland HBCUs

	Year 1	Year 2	Year 3	Year 4	Total per expenditure type
COPPIN					
2 new faculty members	300,000	300,000	150,000	150,000	900,000
6 graduate assistants	300,000	300,000	150,000	150,000	900,000
2 research start up packages	400,000	-	-	-	400,000
Faculty/staff recruitment	20,000	-	-	-	20,000
Student Graduate Asst. recruitment	15,000	-	-	-	15,000
Subtotal	*$ 1,035,000*	*$ 600,000*	*$ 300,000*	*$ 300,000*	*$ 2,235,000*
BOWIE					
2 new faculty members	300,000	300,000	150,000	150,000	900,000
6 graduate assistants	300,000	300,000	150,000	150,000	900,000
1 research start up package	400,000	-	-	-	400,000
Faculty/staff recruitment	20,000	-	-	-	20,000
Student Graduate Asst. recruitment	15,000	-	-	-	15,000
Subtotal	*$ 1,035,000*	*$ 600,000*	*$ 300,000*	*$ 300,000*	*$ 2,235,000*
MORGAN					
2 new faculty members	300,000	300,000	150,000	150,000	900,000
6 graduate assistants	300,000	300,000	150,000	150,000	900,000
2 research start up package	400,000	-	-	-	400,000
Faculty/staff recruitment			-		20,000

	20,000	-		-	
Student Graduate Asst. recruitment	15,000	-	-	-	15,000
Subtotal	*$ 1,035,000*	*$ 600,000*	*$ 300,000*	*$ 300,000*	*$ 2,235,000*
UMES					
2 new faculty members	300,000	300,000	150,000	150,000	900,000
6 graduate assistants	300,000	300,000	150,000	150,000	900,000
2 research start up packages	400,000	-	-	-	400,000
Faculty/staff recruitment	20,000	-	-	-	20,000
Student Graduate Asst. recruitment	15,000	-	-	-	15,000
Subtotal	*$ 1,035,000*	*$ 600,000*	*$ 300,000*	*$ 300,000*	*$ 2,235,000*
TOTAL	**$ 4,140,000**	**$ 2,400,000**	**$ 1,200,000**	**$ 1,200,000**	**$ 8,940,000**

Notes:

1. Faculty member salary and fringe are combined.
2. Graduate assistantship costs include tuition and stipend.
3. Research start-up package provides seed monies to faculty to implement research with goal of attracting external funds to projects.
4. Faculty recruitment costs include advertising, travel, relocation and other costs associated with new hires.
5. Student graduate assistant recruitment costs include advertising, travel and other costs associate with new hires.

In addition to the $8,940,000 in program development cost, the Program Task Force recommends that an additional $100,000 be provided to support promotion of the new clean energy academic programs to recruit top students across the U.S. and internationally to the programs and build program and research outcomes awareness. These funds could be administered by individual HBCUs or a consortium of HBCUs. In addition to potentially forming a supportive marketing consortium, the Program Task Force proposed that the Maryland Clean Energy Center add the HBCUs to its "Research and Development in Maryland" webpage. Lastly, as a part of the MEA's normal promotional activities surrounding clean energy, the MEA agreed it would promote HBCU programs when appropriate.

Possible New Resources

The Maryland E-Nnovation Initiative Program (Chapter 532, Md. Laws 2014), enacted by the General Assembly, and signed into law in 2014, creates an initiative allowing for the auctioning of varied tax credits to the private sector to match higher education funding to attract the best and brightest talent to Maryland universities. This program is to create globally recognized research and development opportunities that maximize Maryland's innovation assets and create private sector investment and jobs. This program will leverage public and private sector capital to fund endowed chairs in targeted areas of science and technology research to include: cyber technology; energy and environmental sciences; nanotechnology and materials sciences; advanced medical and public health science; quantum computing and engineering; transportation, space and aerospace sciences; biometrics; gerontology; neurosciences; language sciences; and high-tech manufacturing processes. The endowment would go toward funding professorships, endowed chairs and related private-public partnerships. As originally envisioned, Maryland's higher education research universities would match funds for research endowed faculty positions in the aforementioned areas.

- The Program Task Force recommends that a portion of the Maryland E-Nnovation Funds target building capacity in the area of energy and sciences (environmental, materials engineering, etc.) for Maryland's HBCUs. E-Nnovation funds coupled with the Program Task force funding recommended here would create a critical mass at Maryland's HBCUs with energy research and Ph.D. programs, which in turn would attract graduate students and create a pipeline of energy professionals for jobs in Maryland's emerging energy sector.

Possible Synergies with Private Industry and Minority Business Enterprises

Applied sciences and collaborations between industry and academia is a critical component of economic development in the United States and other leading global economies. The opportunity presented by the Maryland Offshore Wind Act for the HBCUs to develop clean energy Ph.D. and certificate programs allows for the development of a unique approach to strategic collaborations between HBCUs and Minority Businesses Enterprises (MBEs) on applied sciences, R&D, and technology commercialization.

These opportunities can leverage traditional academic research activities and interests with the interest of minority engineering, manufacturing companies and clean energy investment funds in a manner that helps achieve the State's economic development and energy portfolio mix objectives. This type of collaboration will help increase the global visibility of HBCUs, thereby attracting students and faculty from markets unaware of Maryland's HBCU academic assets and its leadership in clean energy career choices.

Historically, limited funding and access to capital have constrained the growth of HBCUs and MBEs. These entities receive fewer R&D grants compared to larger universities and companies, which can be enhanced strategically by combining forces to jointly apply for financial resources. New HBCU and MBE alliances with large companies will generate components of larger R&D activities and create distribution channels to bring commercialized technology to the market.

In addition to the instant Program Task Force State funding and E-Nnovation funds, including the associated faculty and staff, federal funds can be leveraged to include MBEs directly and in collaboration with the HBCUs on R&D and technology commercialization opportunities.

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) are federal government programs in which federal agencies with large R&D budgets set aside a small fraction of their funding for competitions among small businesses only.

The SBIR and STTR have four program goals:

- Stimulate technological innovation
- Use small business to meet federal R/R&D needs
- Foster and encourage participation by the socially and economically disadvantaged small businesses, and those that are 51 percent owned and controlled by women, in technological innovation
- Increase private sector commercialization of innovations derived from federal R/R&D, thereby increasing competition, productivity, and economic growth

Each fiscal year, the 11 participating SBIR and STTR federal agencies set aside the following percentage of their extramural R&D budgets over $100 million. Extramural refers to federal funding that an agency

awards to external entities such as universities, national laboratories, and large businesses to address the principal agency mission needs. The STTR program requires collaboration with a non-profit research institution and applies to agencies with greater than $1 billion in extramural R&D: DOD, NIH, NSF, DOE, NASA.

	FY 2011	***FY 2012***	***FY 2013***	***FY 2014***	***FY 2015***	***FY 2016***	***FY 2017***
SBIR	2.5%	2.6%	2.7%	2.8%	2.9%	3.0%	3.2%
STTR	0.30%	0.35%	0.35%	0.40%	0.40%	0.45%	0.45%
Combined	**2.80%**	**2.95%**	**3.05%**	**3.20%**	**3.30%**	**3.45%**	**3.65%**

The U.S. Department of Energy issues Funding Opportunity Announcements inviting small businesses to apply for SBIR/STTR grants on topics in areas such as:

- Clean Energy
  - ✓ Renewable Energy (energy production and use in buildings, vehicles, and industry) and Electricity Delivery and Reliability
- Basic Science and Engineering
  - ✓ Fundamental Energy Sciences, including materials, life, environmental, and computational sciences, and Fusion Energy, High Energy and Nuclear Physics
- Nuclear Security
  - ✓ Environmental Management and Nuclear Nonproliferation

Other Maryland funding sources facilitate collaboration between the HBCUs and MBEs, such as the Maryland Technology & Development Company (TEDCO) and the Maryland Clean Energy Center; both of which have bonding capabilities to finance buildings, equipment, and related infrastructure at government rates for funding on behalf of companies, universities and non-profit organizations to support and promote economic development.