Clean Energy Education and the Energy Transition Agenda

Abstract

Awareness of the effects of global warming has become mainstream and drives the need to reduce dependence on fossil fuels. The urgency to transition to clean energy (CE) sources is apparent. Growth in rapidly developing clean energy technologies and their manufacturing industries drives increased demand for graduates trained in these areas. CE Education is the evolution of traditional disciplines to educate candidates to meet the demand for technicians to support the global energy transition away from fossil fuels. Engineering and technology education must be designed to prepare students with skills for energy sector employment. Students will be involved in designing, manufacturing, managing, and implementing CE technology during their careers.

This literature review serves as an introduction to the intersecting bodies of knowledge that promote changes to engineering technology curricula focusing on CE Education. The current landscape needs a social justice frame of reference to examine equal access to CE educational investments, engaging underserved communities, and placing candidates in living wage jobs. CE education intersects workforce, industry, and education, so exploring their motivations gives insight into common goals and how to promote collaboration.

Similarly, reviewing organizational change theories suggests how to enact progress in CE education pathways. Establishing CE Education programs is challenging because alternative energy technology and sustainability are multi-disciplinary topics and don't fit under any single discipline. Educational theories are explored to frame effective ways to present CE education in the rapidly evolving and multi-disciplinary field. Finally, evaluating current government and business environments regarding CE gives awareness of the market forces, support, and demand for promoting education in CE. The review concludes by identifying best practices and serves as an action plan for establishing CE education pathways.

I. Introduction

Clean Energy and Education in the energy field must be defined to understand this paper fully. The terms *clean energy* and *renewable energy* are used interchangeably to identify sources of energy production that do not contribute to the production of greenhouse gases that drive global warming. Clean energy includes nuclear power, but renewable energy does not because, like fossil fuels, there is a finite amount of nuclear fuel on earth; thus, I prefer to use the term clean energy because nuclear power can support the near-term carbon reduction goals. Growth in the rapidly developing clean energy technologies and their manufacturing industries drives increased demand for graduates trained in these areas. Clean Energy Education is the evolution of traditional disciplines to educate candidates to meet the demand for technicians to support the global energy transition away from fossil fuels. Engineering and technology students must be familiar with the applications and implementations of clean energy technologies. Establishing Clean Energy Education programs is challenging because alternative energy technology and sustainability are multi-disciplinary topics.

Research following this literature review will use mixed methods in a transformative theoretical framework to determine best practices for creating clean energy educational curricula and apprenticeships. The literature review determines the research surveys, interviews, and coding content. A review of the US-focused literature on Clean Energy Education and supporting topics informs the reader about the status of clean energy initiatives related to apprenticeships, pertinent legislation, the Clean Energy transition movement, and the Technical Education and apprenticeships that will support it. The US Department of Labor clarifies that apprenticeships combine paid on-the-job training with classroom instruction to prepare workers for highly skilled careers [1]. This literature review aims to reveal how to improve the educational opportunities for current and future technicians in clean energy industries with a focus on the author's home state of New York. New York State ranks among the top five states for green transition, such as third by the US Green Building Council, and second in the US News & World Report, which looks across three dimensions: environmental quality, eco-friendly behaviors, and climate-change contributions [2].

This topic is essential now as 2023 finished as the hottest year in recorded history. Physical evidence of climate change is being experienced across the globe, such as drought, water and food scarcity, severe weather, and rising sea levels. The socioeconomic impacts of these physical effects of global warming continue to grow. Unless countries commit to climate action on energy transition, including investment in technology, manufacturing, and education to support reducing greenhouse gas emissions, these conditions will continue to worsen [3]. On managing the energy transition, “these adjustments can be best supported through coordinated action involving governments, businesses, enabling institutions, and extending planning and investment horizons.

This action would need to be taken in a spirit of unity for two key reasons: first, the universal nature of the transition means that all stakeholders will need to play a role; second, the burdens of the transition will not be evenly felt, and, for some stakeholders, the costs will be much more difficult to bear than for others [3]. Federal and state governments are funding clean energy research development and education for the transition. In parallel, the industry has unfilled positions and needs well-trained clean energy technicians [4], [5]. Thus, technical education

must be designed to prepare students with skills for energy sector apprenticeships and employment.

A. Reasoning

In conceptualizing the current landscape of clean energy education, it is helpful to point towards relevant *educational theories*, *workforce, industry, and educator collaborations*, *organizational change theories*, and *government and business studies* as informing an understanding of the "state of play." The curriculum delivery method can be optimized by understanding educational ideas such as apprenticeship, activity theory, and other developmental theories. Therefore, educational theories are explored to frame effective ways to present clean energy education in the rapidly evolving and multi-disciplinary topic. Clean energy education intersects workforce, industry, and education, so exploring their motivations gives insight into common goals and how to promote collaboration. For example, details of the problem of the gray wave (the baby boomer generation retiring without technicians to succeed them) and what critical skills are being lost are understood. Once the skills are known, they can be converted into the curriculum to teach essential skills. Similarly, reviewing organizational change theories suggests how to enact progress in clean energy education pathways. Finally, evaluating current government and business environments regarding clean energy gives awareness of the market forces, support, and demand for promoting education in clean energy.

B. Motivation

There is a greater good and motivational purpose behind clean energy training and apprenticeships. Consider Deleuze and Guattari's theories on Thinking with Desire and how the results directly benefit others and, on a broader scale, the community and, indirectly, the environment [6]. Deleuze and Guattari see desire as an internal force, as researchers, driving our knowledge contribution. "We desire, not because we lack something that we do not have, but because of the forces and action that are actively becoming" [6]. This project is a continuation of 'becoming' a doctoral student professional, researching and constantly evolving.

Climate change and the "wicked problems" [7] associated with it, are a global reality. Unfortunately, today's leaders tend to focus on the current rather than issues that will significantly impact the future [8]. Culturally, many people have not accepted the urgency of climate change. However, renewable energy resources appear to be one of the most efficient ways to curb the environmental problems associated with development [9]. Dincer states that greenhouse gases (GHGs) are the most affected by energy consumption and the resultant pollutants [9]. Improving the energy efficiency of all buildings and the types of energy production used are a big part of the solution to reducing GHGs.

C. Background

In 2019, New York State passed the Climate Leadership and Community Protection Act (CLCPA). The CLCPA commits New York to incrementally achieve net zero greenhouse gas emissions by 2050. The CLCPA accelerates the development of renewable energy, energy storage technology, and climate-related equity in disadvantaged communities. The growth of clean energy technology for solar, wind, and geothermal projects drives the need for Clean Energy Technicians. The language of the CLCPA includes environmental justice provisions,

such as setting a target for disadvantaged communities to receive 40 percent of the overall benefits from the state's climate programs [10].

The job market growth in these areas has changed the skills students need to compete for clean energy jobs. Leaders of educational and community institutions must be informed of the changes, add them to the curriculum, and be accountable for the results. Educators and the business community must work collaboratively to prepare students for the growing job opportunities in clean energy. The New York State Energy Research and Development Authority (NYSERDA) is collaborating with education and industry to provide funding opportunities now and continuing next year [5]. Successful educational initiatives get business associates to join and form an advisory board to work together in deciding academic focus areas [11]. Key partners like Viridi Parente, an energy storage company, and National Grid, New York's electric utility company, have joined the effort. The research goal that will follow from this literature review is how to improve the educational opportunities for current and future engineers to work in clean energy industries by creating programs designed to prepare students for energy sector jobs.

II. Literature on Clean Energy Education and the Energy Transition Agenda

A. Literature Review Development

A literature review is a survey of scholarly articles on a specific topic to provide an overview of current knowledge, theories, methods, and gaps in the existing research [12]. Topical aspects of the research question frame the literature review and provide an understanding of the challenges facing technical education today. The literature review reflects on and researches the subject and how the issues contribute to the literature [13]. This literature review begins with knowledge areas that support improving clean energy educational opportunities for current and future technicians in clean energy industries.

Existing literature was reviewed to identify key skills development approaches and strategies within the context of the fast-moving and technology-intensive clean energy industry, using a thematic approach to consider the following context: Implementation of CE Education requires knowledge of workforce development, community, government coalitions, funding, and policy. Research activities focus on the best practices in these areas and are informed by socioeconomic factors that influence the findings' scope and impact on social justice. The research design and implementation plan are created from what is learned in the literature review, using research tools, and methods aligned with supporting theories.

1. Illuminating Truths in a Literature Review

As a writer, Lamott's TED_R speech video [14] is motivational about finding the truths we wish to reveal through writing. I want to reveal the "truth" that advances in clean energy technology and the rapid growth in the CE sector manufacturing, installing, and operating renewable energy machinery are driving demand for graduates trained in these areas [14]. This transformation is being funded by government and industry. Renewable energy installations support reducing our carbon footprint to reduce the risks inherent in global warming and are tied to the greenhouse gas contributions of using fossil fuels for our energy needs. The literature review ties the transformation to education because of the number of unfilled positions in the industry and the

lack of educational pathways to prepare students to graduate with the skills necessary to get these renewable energy positions in the industry. The additional truth is that we can contribute to social justice reform by connecting with underserved communities to give them education and skills training in clean energy [14]. Then, they can be the ones who get living wage jobs and ultimately pull their family and their communities out of poverty and become upwardly mobile.

2. Inclusion and Exclusion Criteria Approaches in a Literature Review

As an example, a formal inclusion and exclusion criterion plan for screening search results is presented in Ummihusna and Zairul's 2021 article to determine which articles would be down-selected for full review. Intuitive exclusion criteria such as a date cutoff, type of reference cutoff, and peer-reviewed journals help pare down the list of references to be more deeply investigated [15]. Reviewing an article's abstract is the first step in the selection process, and then reading the conclusion to see if that article informs our research. We must resist the urge to follow interesting branches from the main topic in these exclusion and inclusion criteria to help the researcher stay focused.

Bork and Mondisa's 2022 article presents a practical five-stage approach where the outcomes of each stage provide a scoping literature review [16]. The stages are inclusion and exclusion criteria; a reduced batch of references for study from the eligible references, and then literature data for analysis. The last outcome is to identify current literature trends and potential research gaps that will be written about [16]. The author's experience as a career professional engineer and educator with a sustainability focus shapes the exclusion criteria. To narrow the research body of knowledge, only literature that addresses educational pursuits or techniques in teaching clean energy in the US, uses theories to support the motivation and effectiveness of industry-driven clean education, or provides methods for positive social impact are included.

B. Results: Knowledge Areas of Figure 1

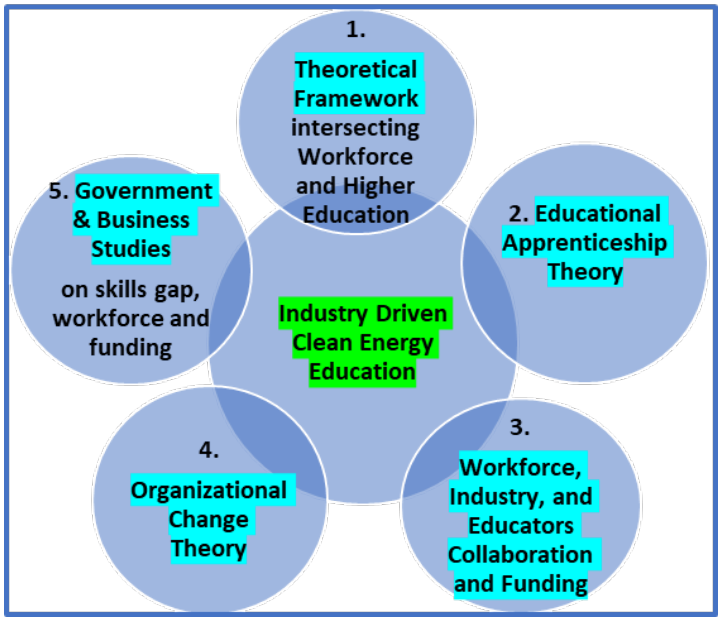

Figure 1. Literature Review Concept Map

Multiple sources on clean energy technical education are organized into five areas: theoretical framework, educational theory, workforce, industry, and educators collaboration and funding, organizational change theory, and government and business studies.

1. Theoretical Framework

Technical training is tailored to improve the educational opportunities for current and future technicians who work in clean energy industries and to prepare certificate- and associate degree-program students for clean energy sector jobs. The transformative theory explores the social mobility potential of providing degree apprenticeship pathways, particularly from degreed apprenticeships [17]. Transformative Paradigm theory supports the enthusiasm to change people's lives, which "is a framework of belief systems that directly engage members of culturally diverse groups with a focus on increased social justice" [18].

2. Educational Theories

Many authors developed apprenticeship as a social theory of learning in various areas of cognition and learning, but few have explicitly focused on apprenticeship. It is, however, relevant: Pratt in 1992 and Guile & Young in 1998 offer theoretical underpinnings that support an identification of "best" pedagogy in this area. These researchers give context to developing a clean energy curriculum that satisfies apprenticeship training. Pratt mentions four main elements in understanding apprenticeship: "the apprentice as learner, the idea of trade or craft knowledge as fixed and unproblematic, the master as teacher and the idea that learning in workplaces is a form of context-bound understanding not conducive to transfer" [19].

Guile and Young explain that we must move away from the lecture mode, where learning is a simple transfer of knowledge, to "learning as a process in which the apprentice is involved in 'learning by doing' with the 'master' as the major role model" [20]. Therefore, it is essential to understand the different pedagogy used in formal education versus apprenticeship. Vygotsky defined the 'zone of proximal development' as "the distance between the actual development level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more able peers" [21].

Additionally, the use of Activity Theory to create impactful educational programs is included. Understanding innovation in education using Activity Theory ensures completeness in the review of educational methods [22]. Several aspects of innovative educational settings were identified as background literature necessary to understand how to bridge the gap between education and industry goals. Lewis-Charp discusses creating an authentic learning community where collaboration among students, faculty, support staff, community, and industry groups enhances student success [23]. By providing hands-on, industry-driven education to underserved minorities, immigrants, and the economically challenged student body, we transform our graduates' lives. With the skills to land gainful employment, graduates can take care of themselves and their families, rise out of poverty, and become upwardly mobile in society. As graduates and their families benefit, so do the neighborhood, local businesses, and community.

3. Workforce, Industry, and Educators Collaboration and Funding

To analyze institutions operating at the nexus of education and clean energy, understanding the organizations that work together and within government policy and funding programs is necessary. A preliminary understanding of such issues as skills shortages is gained from Workforce Development Boards' research that engages employers and industry in preparing workers for available jobs. Educators are part of a "patchwork quilt" of programs in the public workforce system. The level of services provided, coordination across programs and organizations, and state and local policies differ across the country [24]. Two-year colleges that "confer associate's or two-year degrees as their highest educational award, but they also may award certificates for programs that last from only a few days or weeks to those that take more than a year to complete" are vital for designing training [25]. When conclusions and findings are made, creating and implementing an action plan is enhanced by reviewing literature produced by collaborative groups such as the Century Foundation [26].

One primary source of funding to understand is the Workforce Innovation and Opportunity Act (WIOA). The WIOA law was passed in July 2014 to "transform the workforce system to help job seekers and workers succeed in the labor market and match employers with the skilled workforce they need to compete in the global economy" [27]. Strong collaboration among government, industry employers, training providers, educational institutions, service and advocacy organizations, and philanthropic organizations supports the effective delivery of workforce training and services [28]. Additionally, The Inflation Reduction Act of 2022, "modifies and extends the clean energy Investment Tax Credit to provide up to a 30% credit for qualifying investments in wind, solar, energy storage, and other renewable energy projects that meet prevailing wage standards and employ a sufficient proportion of qualified apprentices from registered apprenticeship programs" [29].

4. Organizational Change Theory

Leaders of partnering organizations such as local community groups, manufacturers, and colleges must be willing to compromise on the engineering and technology curriculum, methods, and alignment with employer needs. Understanding organizational change theory provides insight into the best approach to establishing a robust clean energy program. The leadership is responsible for motivating their staff to support the creation of clean energy apprenticeship programs. Although, over time, staff members will re-create and reform the institution's structure through their actions, "theoretically, humans can alter structures through their action, realistically the rules and resources within the structure simultaneously enable and constrain human action" [30]. Institutional response is explained by Oliver as "the convergent insights of institutional and resource dependence theories demonstrate how organizational behavior may vary from passive conformity to active resistance in response to institutional pressures, depending on the nature and context of the pressures themselves" [31].

Astin and Astin propose the premise that everyone can lead and affect change. "A leader, in other words, can be anyone - regardless of formal position - who serves as an effective social change agent. In this sense, every faculty and staff member, not to mention every student, is a potential leader." [32]. Astin and Astin's Principles of Transformative Leadership in higher education are slightly overly optimistic. However, I agree that these changes will not happen

without effective leadership. Likewise, transformational change cannot occur without examining the data and choosing focused efforts on critical areas.

When analyzing research findings and creating an action plan, the use of Bolman and Deal's change theory frames of reference or "lenses" of Structure, Human Resources, Political, and Symbolic; are helpful to fully explore all dimensions of clean energy education for complete understanding of the challenges and improve the findings [33]. I look for mistakes to avoid, such as not flooding the market with more training centers than the number of technicians. A right-sized, steady approach to meet the demand is recommended [34].

5. Government and Business Studies on Skills Gap, Workforce, and Funding

This section focuses on understanding where the skills gaps are and the future of work in manufacturing [35]. Other sources help to discover what made clean energy training programs successful. Implementation requires knowledge of workforce development, community and government coalitions, funding, and policy. We must understand and address workforce development challenges in low-income communities. Research activities should consider socioeconomic factors to ensure that the final program provides impactful recommendations for underserved communities. Janet Yellen, Chair of the Federal Reserve System, is convinced that career and technical education has enormous potential to improve the lives of Americans in low-income communities and that apprenticeships have a more significant role to play [36]. Technical training can be the path to upward social mobility.

As New York transitions away from fossil fuels, different skill sets will be required for building designers, contractors, owners, and operators. To meet the demand for green building professionals, the State University of New York (SUNY) has invested heavily in university- and college-level workforce training programs. The CLCPA includes $6 million awarded to campuses across the state to provide training for the clean energy workforce and $9 million through apprenticeships, internships, and educational training programs when developed with industry partners [6].

The clean energy industry in western New York is extensive, encompassing many businesses across the region. The sector comprises 9,500 firms involved in one or more of the five subsectors of the clean energy industry. Understanding where clean energy businesses are can help academic institutions focus outreach efforts for industry partnerships and workforce engagement [37]. Some common considerations when building a training pipeline include location, the format of the training, materials required, and trainer certification. In addition, a collaborative effort should be made to perform a needs and gap analysis to identify the current workforce demand in each skill type and identify currently available training.

Meeting the demand for clean energy workforce positions is a significant effort. The wind energy industry employs more people than coal, and the solar industry employs more people than the oil and gas sectors combined [38]. The training program must follow a framework of standards to ensure the quality of the renewable energy curriculum. Quality training programs require faculty to be professionally trained in renewable energy. Faculty development will be vital in supporting and growing educational programs [38].

The Interstate Renewable Energy Council (IREC) credentialing program gives clean energy training providers accreditation and certifies their instructors. IREC focuses on the best training practices for the clean energy industry in North America, and although the program is voluntary, it is highly respected [39]. Applicants must apply for accreditation and be audited under their standards [39].

New York (NY) State's Climate Act supports creating clean energy worker education programs as part of New York State's transition away from fossil fuels. The Climate Act investment plan requires that 35%, with a goal of 40% of the benefit of investment, be delivered to underserved minority communities, as shown in purple in Figure 2.

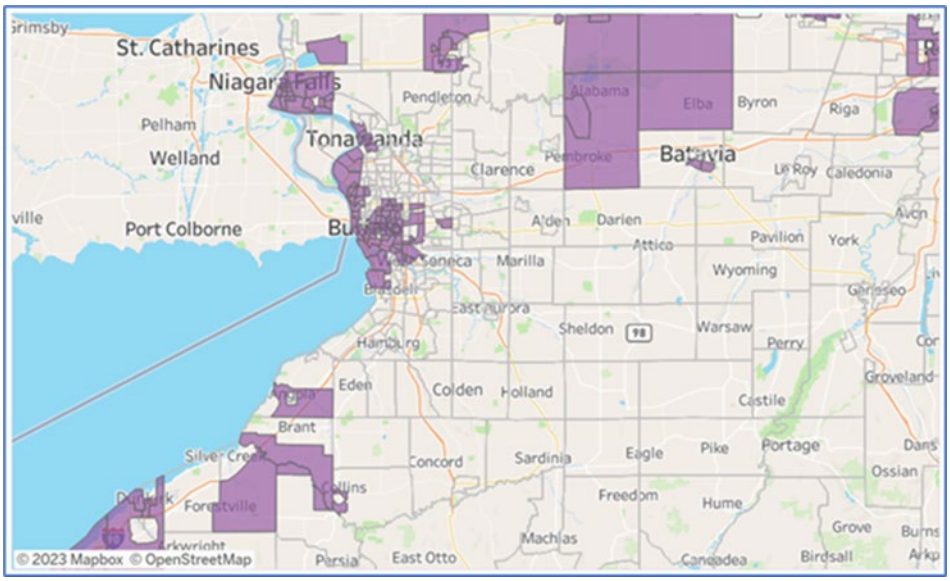

Figure 2. NY State Climate Action Council Scoping Plan-Disadvantaged Communities Map [40]

The Climate Act defines Disadvantaged Communities as "communities that bear burdens of negative public health effects, environmental pollution, impacts of climate change, and possess certain socioeconomic criteria, or comprise high concentrations of low- and moderate-income households." [40].

The NY State Climate Action Council states that projects support the "creation of jobs in clean energy businesses that are in New York and in businesses that serve Disadvantaged Communities, with dedicated support for minority- and women-owned business enterprises to innovate and actively participate in the transformation" [40]. Communities meeting the definition of "disadvantaged" are shown in purple in Figure 2, Western New York segment of the NY State map [40]. I believe in implementing the CLCPA initiatives, which require knowledge of workforce development, community, government coalitions, funding, and policy. We must understand and address workforce development challenges for the most impact in low-income communities.

III. Conclusions

Investments in clean technologies and infrastructure by both government and industrial entities have the potential to address climate change by reducing greenhouse gas emissions while simultaneously creating high-quality and well-paying jobs in what has become a rapidly growing clean energy economy. Educational institutions must develop education and training programs in clean energy to attract and train students who can satisfy the job growth in this important clean energy business sector.

A. Vision

The broader clean energy training vision is to provide a curriculum supporting a pathway from high school to workforce training and the highest achievement in renewable energy, such as doctoral degrees. Workforce training is satisfied by developing a curriculum at the 100 level with significant hands-on training. State colleges offer clean energy curricula at the 200 and 300 levels, with more math and science behind the topics.

By focusing on bridging the gaps between workforce curriculum, non-credit, and credit-bearing certificates, we can provide a progression of stackable courses that build toward successively higher degrees. These broad ideas are used to create risk reduction plans around liabilities and capitalizing on strengths. Finally, research findings are used to make action plans for implementing a clean energy program that satisfies the Climate Act goals using bold, innovative approaches despite the uncertain outcomes.

B. Cultural Resistance

Acceptance of climate action science is necessary for the success of these initiatives, and that has been problematic due to the emerging political polarization. With climate change being a political platform issue, the left or Democratic Party primarily supports legislated actions on clean energy. The right, or the Republican Party, largely dismisses climate change actions in favor of a robust fossil fuel energy industry. Of course, there are exceptions. The general public may also follow these political platforms. They may not be ready to adopt clean energy technology transformation in favor of the convenience and cost-effectiveness of fossil fuels currently enjoyed. Another more profound challenge is getting government, business, and educational partners to interact and work as a team to get the money into the hands of nonprofit organizations and citizens of the community.

C. Increased Social Justice

Socioeconomically conscious research is required, and “The role of the researcher in this context is reframed as one who recognizes inequalities and injustices in society and strives to challenge the status quo, who is a bit of a provocateur with overtones of humility, and who possesses a shared sense of responsibility” [41]. Implementation requires workforce development, community, government coalitions, funding, and policy knowledge. We must understand and address workforce development challenges in low-income communities because technical training can be the path to upward social mobility. Workforce training centers (WTC) and

community colleges can contribute to a future in which Western New York (WNY) achieves greater economic prosperity while improving energy sector capacity and a healthy environment.

D. Community Collaboration

The researcher, workforce development leaders, and SUNY colleges could form a project team to communicate, share curriculum, and write articulation agreements to thread the training sequence together to achieve an action plan for clean energy technician investment. Training center leaders should include the community group People United for Sustainable Housing (PUSH) Buffalo, whose mission is to mobilize neighborhood residents to create quality, affordable housing, expand local hiring opportunities, and advance economic and environmental justice. A primary focus is building a community solar future independent of utilities [42]. In addition, WTCs should join the WNY Clean Energy Consortium, which SUNY institutions established to benefit from collaboration by including academic and business stakeholders. The consortium strives to act as a catalyst to advance clean energy and efficiency programs for workforce training, credit-bearing training, and entry into academic degrees [43].

E. A Living Document

Follow-on research is for designing educational programs with pathways for nontraditional and underserved learners to enter apprenticeships and degree programs that will lead to gainful employment in the Clean Energy sector. The clean energy industry, where technical knowledge is constantly evolving, has educational providers struggling to keep up with the pace of technological advancement. Traditional education pathways are not producing technicians ready for hire, and graduates may not have the desired skills.

As the lead researcher, I will form a project team of community, education, industry, and workforce development leaders to communicate, share curriculum, and write articulation agreements to thread the training sequence together to achieve an action plan. Researchers with a socioeconomic consciousness and the ability to “recognize inequalities and injustices in society and strive to challenge the status quo, with overtones of humility, and who possess a shared sense of responsibility” drive social change [44].

Implementing CE Education programs requires knowledge of workforce development, community, government coalitions, funding, and policy. Research activities focus on the best practices in these areas and are informed by socioeconomic factors that influence the findings' scope and impact on social justice. Social justice is advanced by providing equal access to these educational investments, engaging underserved communities, and placing candidates in living wage jobs [41], [18].

F. Future Research

Future research should explore Sustainable design and leverage government incentives. I completed a one-year Advanced Certificate in Sustainability from the University at Buffalo, which focused on environmentally conscious behaviors, policies, choices, and operations from a global point of view. Sustainability should be studied and shared in the context of communities. For example, if Sustainable Leadership was taught to clean energy partners, these leaders could

train their staff on responsible sustainability behaviors, promoting understanding and driving behaviors that help reduce the environmental impact of industrial and university operations and expansions.

Filho's article [45] uses a precise definition of "sustainable development" as it pertains to universities in that new facilities should follow the latest sustainable design criteria, such as Leadership in Energy and Environmental Design (LEED) certification. The Green Building Council is a nonprofit organization that certifies environmentally sustainable businesses, homes, hospitals, schools, and neighborhoods [46]. They promote green practices and education worldwide through their LEED performance criteria. LEED certification emphasizes state-of-the-art strategies and certifies buildings according to the site's Sustainability, water efficiency, energy use and impact on the atmosphere, materials and resources, indoor environmental quality, and innovation and design [46].

Future research should also follow technological advancements in renewable energy. It is crucial for research and development in renewable technology to continue and for education programs that support the technology to be developed. Academic research on energy alternatives such as fuel cells, smart coal technology, biofuels, nuclear energy, wind, and tides helps society progress toward an environmentally sustainable energy future [47]. As students move into higher levels of education, they can work on getting lesser-known energy systems ready for commercial viability and be part of developing technical training for these new systems. Finally, these clean energy efforts are essential in reducing greenhouse gases and slowing global warming.

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