Renewable Energy Technician Education: Lessons from the German Energiewende

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Abstract

The renewable energy sector poses a moving target for technical educators, especially those charged with workforce preparation at the nation’s two-year colleges. To better answer these questions, a team of renewable energy educators looked to other nations to learn how they had met similar challenges. This paper – and subsequent panel discussion - presents the team’s findings concerning the German response to renewable energy workforce education challenges. Results include key takeaways, notably the importance of energy policy on training efficiencies and effectiveness, the necessity and nature of cultural shift, trends towards reducing specialized degree and instead making use of “legacy” educational pathways, and models for integrating industry involvement. The compiled participant data also provides overarching observations, and educator insights into the similarities and differences in – and influences on – renewable energy technician training in Germany and the U.S.

1.0 Introduction

Preparing technicians for the renewable energy sector is a multifaceted challenge for educators, especially those charged with workforce preparation at the nation’s two-year colleges. Rapid technological advances, shifting economic policies, environmental research results, and even ideological debates actively shape and influence the demands and expectations for this sector’s workforce, all of which impacts the development and implementation of technician education programs. The need for industry involvement and workplace-based learning also presents challenges for workforce educators of any discipline. The question becomes not only what do we train these technicians to do but also how do we effectively do so?

To better answer these questions, a team of renewable energy educators, funded by the National Science Foundation’s Advanced Technological Education program, looked to other nations to learn how they had met similar challenges. Twelve nationally recognized community college faculty and administrators from across the U.S. were selected to participate and to provide expertise in U.S. energy technician education across renewable energy disciplines, including those of biofuels, building efficiency, education policy, energy policy, geothermal power, solar power, and wind power (see Appendix A: Participant List for detailed information). The group undertook two rigorous study tours to meet with technical educators, visit teaching labs, review industry partnerships, and talk with policy makers and government representatives in Australia/New Zealand (2013) and Germany/Denmark (2014) with the goals of providing:

- in-depth exposure to and discussion of energy policy and its impact on renewable energy education in the host countries and in the U.S.
• the sharing of best practices in the content, teaching, certifications, articulation and career pathways for renewable energy technicians among participants and with their international peers
• the use of an online learning collaborative site for knowledge-building activities and to share and disseminate curricula and other learning materials

Germany in particular presented an interesting case. The German Energiewende – or “energy transition” – is an on-going, nationally coordinated, comprehensive undertaking that has two fundamental drivers: the development and deployment of renewable energy sources and an increased and widespread implementation of energy efficiency measures, all of which is occurring in a relatively short timeframe. As would be expected, these efforts have driven the education sector, and in particular those concerned with workforce preparation, to develop strategic solutions for providing workers for this shifting economy.

This study concentrates on the experiences of the study team in Germany during which participant data was collected through the use of surveys, formative reflective reports, summative sector reports and individual participant research report methodologies. As a result, this paper intends to:

• compare, contrast and present pre- and post-travel participant knowledge of renewable energy policy, implementation and technician training in Germany
• summarize and present participant key findings concerning renewable energy technician training in Germany
• summarize and present results of sector-based reports comparing and contrasting US and German renewable energy policy, implementation and educational trends.

Results include key takeaways, notably the importance of energy policy on education efficiencies and effectiveness, the necessity and nature of cultural shift, models for integrating industry into educational programs, as well as the technical specifics of the changes inherent in the Energiewende. The compiled participant data also provides overarching observations, recommended best practices, and educator insights into the similarities and differences in – and influences on – renewable energy technician education in Germany and the United States.

2.0 Overview of Renewable Energy in Germany

“Don’t forget what Germany is doing right now. It’s changing its power supply. The last time an energy supply was changed was the Industrial Revolution.” Paul Hockenos

Germany's renewable energy sector is considered to be amongst the most innovative and successful in the world and it’s Energiewende – or “energy transition” - is remarkable for both its breadth and for its widespread public support, particularly in a heavily industrialized country like Germany. Intended to “provide energy that is secure, economical, and as environmentally benign as possible to Germany”

2, the Energiewende rests on two pillars: the development and deployment of renewable energy sources and an increased and widespread implementation of energy efficiency measures, along with a 10-point energy agenda that encompasses and
coordinates national policies, strategies, growth and development and "designed to ensure that Germany becomes an environmental and economic success story."³

The roots of the transition are frequently traced back to the Chernobyl nuclear catastrophe with at least one participant from the study trip remarking that "to hear one of our speakers recount how the German children could not play outside due to the effects of Chernobyl crystallized the importance to the Germans of protecting one’s own and the significance that energy and environmentalism plays in their future and the future of their children."⁴ Following the Fukushima reactor disaster of 2011, the Energiewende was given even more precedence and a push forward with Chancellor Angela Merkel leading the shut down of 8 of Germany’s 17 nuclear reactors (see Figure 1).

![Figure 1: Nuclear Plant Decommissioning in Germany 2000 – 2020](image)

From *Energy Transition/Energiewende*, Bolle Foundation [⁵]

With this shuttering of nuclear plants, and an overarching goal for “80% of Germany’s electric power to be generated from renewables by 2050”⁶, the Energiewende is well underway. In fact, the amount of electricity produced in Germany from renewable energy increased from 6% in 2000 to over 25% by 2013 (see Figure 2) with the international press reporting that “clean-energy sources such as solar and wind met a record 27 percent of demand in Germany in the first quarter of 2014”⁷ (see Figure 3). By way of comparison, “Germany’s 27 percent is double the approximately 13 percent of U.S. electricity supply powered by renewable as of November 2013.”⁸
Figure 2: Renewable Energy Production in Germany
From Climate Progress, Bernard Chabot [9]

Figure 3: Development of the share of renewable energy sources in gross electric power consumption
From The Energy Transition Progress Report, Germany Federal Ministry of Economic Affairs & Energy [10]
A discussion of the many policy changes and initiatives that have been put in place to support this transition is outside the scope of this paper. However, two incentives were mentioned in regards to policy that participants felt were key in growing renewable energy capacity and thus bear mentioning before moving onto education and educational pathways: the first is the availability of “feed-in tariffs” and the second, and very closely related, is unfettered access to the grid by the populace.

Feed-in tariffs are what the renewable energy producer (whether citizen or utility) receives as payment for each kilowatt (kW) they produce from their systems (see figure 4) and have been widely used by Germany as incentives to increase the spread of the use of renewables for electricity generation (see Figure 4).

![Feed-in tariffs grow renewables](image)

**Figure 4:** Feed-in Tariff Growth in Germany 1990 - 2012

In terms of incentives, the U.S. push for renewable energy source growth begin with rebates, which were available based on the amount of energy an installed service was intended to generate or on a fixed amount as set up in advance. As a participant with expertise in this area explains, these incentives have “slowly transitioned into the tariffs that Germany has had for many years. The primary reason for tariffs being favored over rebates is that they encourage the energy producer to be more efficient by paying for production (kWh) vs. installed capacity (kWp). Also, all electrical users pay for the tariff (through higher rates) rather than the government (taxpayers) paying for rebates.”[12]
With regards to access to the grid, participants noted that “German ratepayers have guaranteed access to the grid. In the U.S., there are increasing numbers of challenges by utilities as to the rules for grid connection, net metering and related issues. In the U.S., connecting to the grid with independent energy systems is only with permission.” By contrast, grid access for all is ensured by Germany’s Renewable Energy Act (one of the key policies underlying the larger Energiewende) and is intended to speed the transition on a local level in that it “guarantees priority grid access to all electricity generated from renewables and is designed to produce reasonable profits. By 2013, more than half of investments in renewables had been made by small investors. The Germans want clean energy, and a lot of them want to produce it themselves.” It was widely acknowledged that providing incentives to those who are generating energy subsidizes their investment in the equipment and systems necessary to do so, which in turn requires access to contribute this energy to the general grid; this was found to be key to growing and sustaining renewable energy capacity. These two factors – feed-in tariffs and grid access - are mentioned only due to their prevalence in the participants’ notes; while there are many other factors mentioned as influencers on the growth of Germany’s renewable energy sector, as noted earlier a deeper discussion of energy policy is unfortunately not possible within the scope of this paper.

3.0 Overview of Education Systems in Germany

The education system in Germany is quite unlike that found in the United States however there are some similarities. For one, education is compulsory in Germany up to age 16 for most students (through lower secondary level). There is also a fairly unified curriculum for the first 4-6 years (approximately to age 10) that is somewhat similar to what is found in kindergarten and early elementary in the U.S. However, at the next level, the two systems diverge remarkably (see Figure 5 below).

At the first stage of the secondary level of schooling (approximately age 10 - 15), students are directed into essentially four distinct pathways that lead to significantly differing outcomes and higher education options. The first of these options, reserved for the most academically talented students, is the Gymnasium (grades 5-12). Successful completion of the Gymnasium results in a diploma and prepares students for university study or for a dual academic and vocational credential. Another option is the Realschule (grades 5 – 10), the completion of which leads to “part-time vocation schools and higher education vocational schools.” Students with high academic achievement at the Realschule, upon graduation, can switch to a Gymnasium and complete the necessary studies for a diploma. A third option is the Hauptschule (grades 5 – 9) which “teaches similar subject matter as the Realschule and Gymnasium, but at a slower pace and with some vocational-oriented courses.” The Hauptschule leads to part-time enrollment in a vocational school combined with apprenticeship training until the age of 18. The last option, available in only some German states is the Gesamtschule, or comprehensive school. It takes the place of both the Hauptschule and Realschule and enrolls students of all ability levels in the 5th through the 10th grades. Students who satisfactorily complete the Gesamtschule through the 9th grade the 10th grade receive the Realschule certificate.
In the upper level (or second phase) of secondary education, options for German students depend on their previous credential. A Gymnasium diploma enables the holder to proceed to university and pursue bachelor’s, master’s, or possibly doctoral degree; it also allows the holder to choose to attend any of the vocational institutions. For students completing the Hauptschule or Realschule, the Berufsschule which combines part-time academic study and apprenticeship – referred to commonly as the “dual system” – is a possibility or students can attend the Berufsfachschule, which offers a more basic vocational training that normally concludes with a less involved apprenticeship. The Berufsschule and other trade schools differ from the university (or their equals, the Fachhochschulen or Kunst, Musik or Filmhochschule) in that control of the program and curriculum rests with the federal government, industry and the trade unions rather than the state or national education boards. Technician training also occurs outside of the school system and can be obtained at a cost from for-profit training organizations; costs for such training may be absorbed by employers or by the state, depending on the student and their situation.
It is worth noting that students in the dual-system are selected for their apprenticeships using a system similar to finding employment; the companies post their openings and students compete for spots. The apprenticeships are expected to continue for the duration of the student’s schooling and learning on the job normally makes up 2-3 days of the student’s schooling schedule with the remainder of their coursework occurring in the classroom; these schedules and the content of the training is coordinated with a great deal of industry and trade union involvement and input. The successful completion of an apprenticeship program leads to certification in a particular trade or field of work; oftentimes, the apprenticeship site hires the graduating student as a full-time employee but not always. Costs of the dual training are split between the state (Lander) and the company, with the company providing most of the support. The company also pays the trainee a salary that we are told is enough to live on reasonably.

Students who are not initially tracked into university can still achieve this goal however switching “tracks” requires a lot of determination as well as some time to go back and recover missing credits. A recent addition, seen during the group’s travels to Butzbach, provides an opportunity for educational advancement to those who have been in the technical workforce for 2-3 years who would like to advance themselves by achieving a higher level of academic completion; for these students, select Berufsschule offer additional training with an option of eventually transferring to university.

4.0 Methodology

4.1 Subjects

As noted in the introduction, the participants in this project are professional educators who are involved in renewable energy technician education (for more information on participants, see Appendix A). Of the twelve participants, nine are educators at the two-year college level, two are full-time administrators of renewable energy programs that operate within the two-year college system and one teaches STEM curricula and administers an advanced program in such at the high school level. The distribution of expertise in the group provided representation for solar energy (3), building efficiency (2), wind power (2), bioenergy/biomass (2) and geothermal energy (1). In addition, two participants provided expertise on educational policy and the administration of renewal energy education programs with all being conversant and well informed on the curricula and methodologies used to educate and train renewable energy technicians.

4.2 Sites Visited

The itinerary for this study tour was developed to provide participants with first-hand exposure to a variety of perspectives on the Energiewende and its impact, with an emphasis on educators and educational programs that could be said to be the equivalent of two-year college level technical programs in the U.S. The group first met in Washington D.C. at the Boell Foundation for a one-day series of lectures designed to provide information on the German school system, the German political structure and the Energiewende itself. Once abroad, the group visited 16 sites including three technical schools/universities, three for-profit training schools, three
industry sites (geothermal plant, biogas plant, wind turbine manufacturer), two energy self-sufficient demonstration villages (Feldheim, Folkcenter), and five government/policy advocacy organizations (for more information on sites visited, see Appendix B). This diversity of sites was intended to assist the participants in better understanding the impact of the Energiewende on technician education from many points of view; indeed, one participant commented that “it is so important to get all these different views of the same transition. There is obviously much consistency (they are addressing the same issue), but more importantly some important disagreements. You can better imagine how government, school systems, private training organizations, public educational organizations, watchdog agencies, standards organizations (COGS), industry, and utilities view the issues and why.”

4.3 Knowledge-Building Activities

Learning activities and deliverables were developed in order to deepen and broaden the knowledge gained by participants while also capturing and preserving their findings and gains both for the participants themselves and for the purposes of dissemination and grant reporting. Most of these activities and deliverables were facilitated and supported through the use of an online “course” site hosted on Instructure’s Canvas course management system (see Figure 6) and reports, discussions and other artifacts were collected on the site as well. Conference calls and webinars were also used to connect the group.

Figure 6: Faculty Learning Project Canvas Site

Reading/Discussion: Prior to travel, participants were asked to review selected readings as posted on the Canvas site each week; topics included the German school system, government structure, technical information regarding renewable energy in Germany and the specifics of the Energiewende itself. These weekly readings were followed by mandatory, guided online discussions.

Pre-Visit Site Reports: Participants were also assigned 1-2 sites that the team would be visiting for which they completed a “pre site visit” report form. This required that they investigate – and
in some cases contact – the schools, agencies or industry sites; these reports were posted to the Canvas site and presented by the authors during a series of webinars. During travel, the pre-visit site reports were also read aloud by the authors while the group was en route to each site; this allowed participants to ask questions and share knowledge and also anchored the experience prior to arrival.

Pre- and Post-Travel Surveys: Completion of pre- and post-travel surveys were required by all participants and used to measure knowledge gained.

Individual Inquiry: Participants, with the assistance of the learning coordinator, selected an area of investigation that was key to their practice as an educator or renewable energy expert. These questions guided the participants’ informal research while traveling and resulted in short reports after travel.

Site visit reports: Participants completed reports for each site visited. These forms consisted of five questions prompts and resulted in formative, reflective reports that captured their experiences at each visit and also acted as informal journals that they could use in the future to identify trends, concepts and/or innovations that they found notable. The reports also served as a record for their continued investigation into their individual inquiry question(s).

Sector Reports: Upon return, participants were paired up on teams based on their specific area of renewable energy expertise to complete sector reports which compared and contrasted the German and U.S. energy industry, educational pathways, industry involvement in education and specific observations about curriculum and/or teaching methodology.

5.0 Results

Overall, the various reports and surveys indicated that participant knowledge about German technician training, renewables industry, Energiewende and schooling system as a whole was greatly enhanced by visiting the many sites, completing the learning activities, and traveling with a group of peers who are also renewable energy experts and skilled educators. The next few paragraphs will take each type of learning activity and expand a bit on the results of said activities.

The pre-travel and post-travel survey instruments were identical in order to better compare responses to items on each (for instrument questions and detailed results, see Appendix C). The questions asked about general knowledge about Germany in regards to schooling, industry, industry involvement in technical education and German policy. As the evaluator for the grant wrote: “It is clear from the pre and post surveys that while the participants had expertise in the U.S., they knew very little (with one exception) about the system in German. The pre survey consists mostly of "I don't know" and "I have no idea" responses when asked about understandings of Germany's educational system, renewable energy policy, renewable energy education and training. By contrast, the post survey responses are long and detailed with many specific instances quoted. Clearly, the group gathered a great deal of information.”

16
The site reports varied from site to site and from participant to participant; some used these forms to capture details and nuances that might be forgotten, others described technical processes and innovations, still others were brief to the point of being close to insufficient. The learning coordinator worked with the participants in the latter group to help identify obstacles and encourage more extended commentary. Participants later noted that this adjustment was helpful to them in that these essentially formative, reflective reports were useful to them in forming responses for their sector and individual inquiry reports.

The sector reports, assigned to participant teams who shared expertise in particular areas of renewable energy (Education, Policy, Building Efficiency, Solar Energy, Bioenergy/Biomass, Wind Power and Geothermal Energy) were summative in nature and deeply detailed (for a table of the sector report findings and recommendations, please see Appendix D). The information reported was thorough, complete and thoughtful and provided ample data to allow for cross-sector analysis. The grant’s external evaluator found these particular reports to be of the highest value and, in her report states: “Taken as a whole, these reports reflect an impressive amount of knowledge that should be compiled and shared on a broader basis. The understandings reflected are deep and are presented not in an "us versus them" tone, but in a reflective tone of comparison that understands the applicable differences in scale, practices, politics and philosophy.”

Participants also provided detailed, well-researched responses to their guided individual inquiry questions. The questions themselves were developed with input from the leadership team and learning coordinator; they ranged from questions such as “what is the relationship between post-secondary technical schools and the geothermal industry” to “what are the processes involved in developing and/or improving successful renewable energy related technical programs” to “what is the typical ratio of full time instructors vs. adjunct instructors from industry teaching in these programs.” These reports also contained sufficient data to allow for their cross-analysis; in addition, there were multiple mentions of several key points. These, as well as reoccurring themes in the sector and site visits, will be discussed in the next section.

6.0 Discussion

Upon reviewing the qualitative and quantitative data offered by the participants in their reports, surveys, discussions and exchanges, it becomes apparent that there are certain that arise across these instruments and across subjects. A more in-depth look at four of the most common topics or observations commented upon by participants follows.

Recommendation #1: Establish and enact a long-term United States national agenda for renewable energy development, use and deployment.

The single most common response from participants regarding what most directly influences the educational pathways and the education of technicians in Germany is the existence of the Energiewende itself. What makes the difference, wrote one, is “Germany’s long-range outlook on energy planning, whereas in the U.S. our plans are typically based on short-term market forces.” This same sentiment was restated often by others: “The most striking thing is that Germany actually has national energy goals with strategies and policies designed to achieve
them and that it is actively monitoring progress and identifying emerging challenges that must be addressed as the policy goes forward. These challenges are very complex and include issues such as the following: how to improve grid connections between north and south Germany; how to design the energy market to synchronize supply and demand…how to coordinate worker education, dislocation, and educational pathways…”18 and “Again the reoccurring theme: energy policy determines the number of projects which affects the number of jobs which affects the number of students. As educators, as administrators, we need to stay on top of policy to anticipate the waxing and waning of these trends. Just seems easier when there is some sense of stability at the policy level.”19 The external evaluator in her review of the data stated this perhaps more succinctly: “Participants viewed the German political and policy system as slightly less volatile than the US system and perceive these differences as positively influencing renewable energy training and education.”16

Recommendation #2: Develop core programs of study rather than “specialty” degrees or certificates.

Another common theme was the increasing perception that “legacy education programs in traditional fields can support and train students who are interested in working in renewable energy, while at the same time offering larger employment potential and more connections with industry.”20 Along this same line of thought, another participant commented that “we have heard many times from a variety of industries on this trip that it is not necessary to create specialized niche programs in this area. The businesses and the students are better served when the programs are based on a solid foundation of electromechanical courses. This strong yet broad core will allow students to transition, if needed, with the market.” Indeed, notes another, “the Germans seem to have moved past the glitz of niche renewable energy training programs and have realized that the skills and knowledge needed to be successful in the renewable energy field are largely transferable from other industries such as electrical, industrial maintenance, and engineering.”21 This has tremendous implications as the participants return to their programs and centers for renewable energy technician education and begin to revisit how their programs might incorporate this new knowledge.

Recommendation #3: Find new and deeper ways to strengthen the collaboration between education, industry and trade unions so that these entities can shape technological education programs.

Not unexpectedly, the accepted practice of industry involvement in the planning and development of all educational programs in Germany was another often mentioned element of the German educational system, especially within the “dual system” model of technical education in which students attend formal schooling for 1-2 days a week and spend the remainder of the week on the job site. These are long-term formal commitments that are arranged through a process much like a regular hire; quite frequently, at the conclusion of several years of study, graduates are hired at their apprenticeship site. One participant noted that “it was almost a cultural understanding that - of course - industry is involved in education. The Germans have had such a long history of apprenticeship and the existing "dual-system" has evolved over many generations, so it was difficult for them to imagine a system like that of the U.S.
where industry is only loosely involved with education (usually in an advisory board capacity). Even at the university level, industry is closely tied to the education sector. In fact most of their graduate degree holders work in industry (unlike the the U.S. where a large number go to academia and work in the numerous U.S. institutions of higher education).”

Another study participant observed that “Germany’s national policy of ‘education-industry-trade union’ consensus when it comes to curriculum development has been a great benefit in workforce development.”

while another, looking at the background of faculty teaching in renewable energy programs stated that “the most significant finding I discovered was just how differently the two systems define industry involvement. In the U.S. we tend to see industry involvement as having industry experts serve on advisory boards, teach as adjunct instructors, and provide potential employment for our graduates. Conversely, the German view of industry involvement is more about...getting students out into industry settings where they can learn from the experts in the field.”

Additionally, there was an increased awareness of how the German model rewards both education and industry when they partner closely to develop pathways, with participants noting that “German companies are eager partners in the system and depend on it for a supply of entry-level workers.”

Several also noted the depth and breadth of industry/education partnerships: “there is an automatic buy-in from industry...industry does all it can to make this interaction flow: providing apprenticeships, providing equipment and advice to training institutions, lobbying government, providing employment.”

Participants observed that some of these practices might be a means for increasing industry involvement in their own educational programs; one in particular intends to pursue “pre-apprenticeships” that allow both the student and the potential industry partner to see if the “fit is right.”

Another was interested in exploring ways to make the connection with industry for the purposes of refining curriculum more rewarding for industry partners.

Recommendation #4: Encourage cultural shift and personal responsibility towards energy conservation.

The last group of participant comments we will discuss are observations about the cultural differences that impact renewable energy adoption and education. Some of these comments related to the overall culture surrounding the Energiewende and the general acceptance of the German populace of the need to move towards renewable energy: “The German perspective on climate change is that “It’s happening. It’s man-made. We can do something about it.”

Others observed differences between the German educational culture and that found in the U.S.: “Education and technical training in Germany are viewed as an investment—neither a cost nor a social program. The German logic seems to be that by educating more people—both citizens, immigrants and visitors—their economy as a whole will be stronger and will generate more revenue.”

But the most common were comments about the culture that has arisen around the pillar of the Energiewende that dictates conservation and efficiency; these were observable actions on the part of the Germans themselves, in every day encounters, that participants remarked on widely. As one of the building efficiency experts noted: “energy efficiency requires a culture shift....and Germany demonstrated that a cultural shift is possible. In the US, operable windows in modern commercial buildings are a rarity, and the "free" cooling and ventilation afforded by "opening the window" is seldom available to building occupants. In Germany, every multi-story building we entered had operable windows in use.”

All of these cultural
observations led to much discussion amongst the participants; several also discussed ways to incorporate and facilitate this type of discussion in their classrooms.

There were, of course, many other areas of interest and many other observations made during the course of this project. Some of these involved the adoption or adaption of German practices such as boosting environmental literacy by contextualizing environmental topics in writing, reading and the arts (in addition to within STEM courses); welcoming very young students (K-2) into post-secondary labs and classrooms to increase their interest in renewable energy careers; exporting education internationally to build good relations and boost exports of expertise and goods; and innovative and thorough ways to encourage women and girls to enter the renewable energy sector. Again, these are but a few of many.

7.0 Conclusion

Although the intent of this study was to determine faculty recommendations for ways to improve technician education in the renewable energy sector, and four such recommendations arose from the many reports, reviews and surveys completed by the participants, in the end at least two of the most oft-mentioned recommendations seem to be almost wishful thinking. Given that the impact of national energy policy clearly was considered the most impactful factor observed by the participants of the study tour, the question must be asked: can U.S. policy be shaped in a way that supports an agenda similar to that of the German Energiewende? It seems unlikely given the historical and current issues plaguing the American governmental leadership and preventing consensus on much less controversial topics. Similarly, suggesting that a cultural shift towards opening windows and switching off the lights when abundant natural light is available could influence popular opinion and thus increase the value placed on energy efficiency careers, also seems a long-term and possibly unlikely goal. That both of these recommendations are based on thoughtful and studied observations made by participants on the study tour is clear, but their practicality for the foreseeable future is likely quite limited.

The other two recommendations may prove more fruitful. That renewable energy technician education programs might benefit from following the patterns observed in Germany and begin to shift away from self-contained specialty programs and towards the practice of adding specialized coursework in renewables to “legacy” programs – such as those focused on electrical or mechatronic core basics – would not be difficult to study, pilot and observe for potential benefits. Redesigning the approach to technician training in this way may allow renewable energy training programs and their graduates to survive and even thrive during the inevitable fluctuations in this sector given that they would have, at the core, a stronger set of transferrable skills. Blending these older and more recent programs may also increase the opportunities for institutional efficiencies, which further increases the likelihood that this may be worthy of further study.

Likewise, developing new ways to deepen the collaboration between industry, education and trade unions – and learning more about how the U.S. might emulate such promising practices such as the German dual-system apprenticeship program – would seemingly strengthen not only the renewable energy education system but potentially all technical education programs. This last recommendation may be the most promising made by this study, a finding that is resonant
with current and future calls for apprenticeship research by the Departments of Labor and Education and increased interest by education-focused foundations. The benefits of a strong partnership between education, industry and labor were clearly evident to the participants in this study.

In conclusion, it should also be noted that while this paper has presented some of the key findings by this group and the data they generated, it does not capture the wealth of knowledge that was presented to the participants and which they in turn collected, personalized, added to, and continue to refine and share as they persist as a network of learners. The group will continue to collaboratively develop their collective expertise and to disseminate lessons learned through publications and presentations to home campuses, environmental agencies and fellow educators.

References

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## Appendix A: Participant List

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<tr>
<th>PARTICIPANT</th>
<th>INSTITUTION</th>
<th>SECTOR</th>
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<td>Dr. Dave Boden</td>
<td>Truckee Meadows Community College, Reno NV</td>
<td>Geothermal</td>
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<td>Professor of Geoscience</td>
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<td>Program Chair, Biotechnology</td>
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<tr>
<td>Co-PI, Bio-Link ATE Center</td>
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<tr>
<td>Dr. Patrick Foster</td>
<td>Santa Barbara City College, Santa Barbara CA</td>
<td>Solar, Building Efficiency</td>
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<tr>
<td>Director, Construction Academy</td>
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<tr>
<td>John Galisky</td>
<td>Lompoc High School Lompoc CA</td>
<td>Integrated curricula, High School programs</td>
</tr>
<tr>
<td>Coordinator, Space, Technology and Robotic Systems (STaRS) Academy</td>
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<tr>
<td>Michael Gengler</td>
<td>Iowa Lakes Community College Estherville IA</td>
<td>Wind</td>
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<tr>
<td>Faculty, Wind Energy &amp; Turbine Technology</td>
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<tr>
<td>Dr. Ellen Kabat-Lensch</td>
<td>Eastern Iowa Community College District Davenport IA</td>
<td>Workforce Development, Education Policy</td>
</tr>
<tr>
<td>Executive Director, Resource Development &amp; Innovation</td>
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<tr>
<td>Executive Director, Adv. Technology Environmental &amp; Energy Center (ATEEC)</td>
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<tr>
<td>Dr. Andrew McMahan</td>
<td>Central Carolina Community College Pittsboro NC</td>
<td>Bio-fuels, Hydropower</td>
</tr>
<tr>
<td>Chair: Department of Sustainability</td>
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<tr>
<td>Jim Pytel</td>
<td>Columbia Gorge Community College The Dalles OR</td>
<td>Wind, Solar</td>
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<tr>
<td>Faculty: Renewable Energy Technology</td>
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<tr>
<td>Dr. Kenneth Walz</td>
<td>Madison Area Technical College Madison WI</td>
<td>Solar, Bio-fuels, Workforce Development</td>
</tr>
<tr>
<td>Director: Consortium for Education in Renewable Energy Technology</td>
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<tr>
<td>Faculty: Chemistry, Engineering &amp; Renewable Energy</td>
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<tr>
<td>Troy Wanek</td>
<td>Red Rocks Community College Lakewood CO</td>
<td>Solar, Workforce Development</td>
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<tr>
<td>Renewable Energy Technology Faculty</td>
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### Appendix B: Sites Visited (by Type)

<table>
<thead>
<tr>
<th>Site Description</th>
<th>Description</th>
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<tbody>
<tr>
<td><strong>Berufliche Schulen Gross-Gerau (BSGG)</strong></td>
<td>Educational institution that “prepares students for the future world of work.” Through collaboration with training companies and guilds, they offer programs (dual-system, professional programs, vocational high school, adult education and apprenticeships) that provide “concrete, hands-on learning” that will prepare students for a changing economy.</td>
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<tr>
<td><strong>Hessian State Office for Technical Training (HST)</strong></td>
<td>Primarily offers training for teachers, training managers, and educational staff at German vocational schools but also provides training for practitioners and educators from partner countries of the Federal Republic of Germany, often at no cost to them. Expertise in seven primary disciplines: IT Systems, Application Systems, Electrical Engineering, Environmental (Renewable Energy and Building Science), Mechatronics, Print &amp; Media Technology and Education &amp; Quality Management.</td>
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<tr>
<td><strong>Berufschule Butzbach</strong></td>
<td>A technical college offering state-certified technical training, including a unique program for existing workers who wish to gain an advanced higher educational credential. The Environmental Technology department includes programs in Energy &amp; Environmental Engineering, Bio-energy &amp; Renewable Resources, Solar Thermal &amp; Photovoltaic, Environmental Engineering, Energy Management/Energy Efficiency.</td>
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<tr>
<td><strong>Technische Universitat Darmstadt</strong></td>
<td>A university that emphasizes technical concentrations. Bachelor of Science degrees are offered in the traditional sciences as well as technology programs (e.g. Applied Geosciences, Environmental Engineering, and Biomolecular Engineering.) All technical areas require an internship. Bachelor-Master of Education degrees are offered in 6 areas of engineering technology for teachers at vocational schools; the Bachelor degree includes both technical and educational courses and qualifies the student to enter the Master of Education program. The Master program qualifies the student to enter an internship as a technical school instructor.</td>
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<td><strong>BZEE Training Center for Renewable Energy</strong></td>
<td>BZEE, a for-profit training company, was “born out of an industry initiative in 2000 to close the skills gap facing the German wind industry.” BZEE offers multiple educational opportunities to students worldwide, often on-site. Existing programs include a six-month advanced service technician training, wind turbine blade repair, safety for offshore service technicians, various electrical safety courses,</td>
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safety training courses for wind turbine technicians and more. BZEE also works with employers to develop customized training packages.

**RENAC Renewables Academy**

A for-profit training and consulting company, the Renewables Academy (RENAC) “provides trainings on green energy internationally and a variety of business services to develop capacities for a sustainable energy supply.” RENAC training is hands-on, manufacture agnostic, flexible, regionally specific, and certificating (MBA Renewables, MS in Global Production Engineering for Solar Technology, etc.). RENAC also works with public sector and financing institutions on topics such as legislation (enabling frameworks, suitable policy, regulation, and market), labor-capacity-needs assessment, how to finance renewable energy, and more.

**Boell Foundation**

(Orientation site - Washington D.C.) Affiliated with the Green Party and headquartered in Berlin, the Foundation maintains 30 offices across the globe. Through the analysis of policy initiatives, standards, and pricing mechanisms, the Foundation seeks to provide the German government, interest groups, and other political groups with information necessary for informed policy discussions. The Foundation publishes analyses of Germany energy policies and perspectives as well as broader pieces on European and global issues related to sustainability, climate change, and related topics.

**Life E.V.**

Life e.V. is a non-profit with expertise in vocational training, school development & labor market integration (especially in the field of renewable energy and environmental education), and gender and climate policy. Leveraging its 25-year history and well-established partnerships with women’s and environmental organizations, LIFE e.V. places students in internships/apprenticeships, provides support and opportunities for young mothers/single parents and immigrants, and is involved with local schools to improve access to renewable energy education for women across Germany and Europe.
| **Agora Energiewende** | An “agora” or forum where key questions of energy policy are discussed in an open and trusting environment. Consisting of the Agora Council and Agora Energiewende staff, this group is jointly funded by the Mercator Foundation (one of the largest private foundations in Germany) and the European Climate Foundation (a joint initiative of several large international foundations in Europe and the United States). The Agora Council is made up of select political decision-makers from national and state levels, strategic players from the private sector and civil society, researchers, and other opinion leaders. The Council meets under Chatham House Rules ensuring that all individual voices stay confidential within the Council thus creating a safe environment. Energy topics discussed and investigated include efficiency and load management, electricity generation, European energy cooperation, electricity market and system reliability, optimization, and grids and storage. The group prioritizes being accessible and transparent. |
| **Federal Ministry for Economic Affairs & Energy (BMWi)** | The focus of this government office is on economic policy. Objectives used to formulate this policy include: (1) Develop opportunities to ensure sustained economic growth and competitiveness with other economies, (2) Ensure a high level of employment, (3) Strengthen small and medium-sized enterprises, (4) Promote new technologies and innovation to maintain economic competitiveness, (5) Link economic and ecological goals, (6) Expand the worldwide division of labor and a free system of world trade, and (7) Ensure a secure energy supply at appropriate prices. To support the broad spectrum of activities to promote economic health, the ministry is divided among ten Directorates-General including Energy Policy, Industrial Policy, and Technology Policy. |
| **German Solar Energy Society (DGS)** | A privately funded non-profit with interests in sustainable energy supply, technical standards and consumer protection, the German Solar Energy Society provides education and promotion of renewable energy applications and usage. Their focus is on solar PV and thermal along with small-scale biomass heating and combined heat and power (CHP). DGS runs the Solar Schule Network which consists of 17 international training programs, publishes well-known instructional books for architects, engineers and installers (“Planning and Installing Photovoltaic Systems”, “Planning and Installing Solar Thermal Systems”, “Planning and Installing Bioenergy Systems”) and, through their collaboration on an 18-meter photovoltaic catamaran, provide opportunities for students to experiment with solar and aquatic research. |
### Wallerstädtener Biogas Plant

The municipality of Gross-Gerau has operated the biogas plant in Wallerstädtener since 2008. The plant has two co-generation engine gen-sets with a total electric capacity of 1,086 kW. The plant produces about 8.3 million kWh per year. This is sufficient to supply around 2,300 households with electricity, and saves approximately 10,000 metric tonnes of CO₂ per year. The biogas plant differs from most U.S. anaerobic digesters in that residues such as manure or food waste are not used. Rather, there is a group of about 50 farmers that supply the plant with 24,000 tons of energy crops such as corn, green rye, sorghum and sugar beets each year. The crops are harvested from a radius of about 10 km surrounding the plant. As a result, the biogas plant has actually stimulated a local energy crop economy.

### Insheim Geothermal Plant

Insheim is a new, small geothermal power plant that came online in October 2012. The plant has an installed capacity of 4.8 MW, apparently sufficient to power about 8000 German homes. Three more geothermal power plants are scheduled to come online in 2015 for an additional 16 MW of installed capacity. Germany’s plan is to have 100 MW of installed geothermal power by the end of 2017. Considering that most power plants will be in the 5-7 MW range, the construction of an additional 12-15 plants in the next 3 to 4 years would be required— an ambitious goal indeed. Nonetheless, the Germans are now world leaders in the technology of stimulating deep geothermal reservoirs for production (aka engineered geothermal systems or EGS), and as experience and knowledge grow, associated costs will decline with time.

### Feldheim

Feldheim is called a "model renewable energy village” that created its own grid (each resident paid $4000 USD) and integrated industry and energy/heat production along with self-government. Its energy components are: 43 turbine wind farm (74 MW), 284 panel solar farm (2700MWh/yr), biogas plant (pig manure to fertilizer and heat/electricity), biomass plant (forest thinning to electricity and heat), its own energy grid, an EV charging station, 10MW Battery storage facility. The results of these integrated components are that the village: 1) sells back 99% of produced electricity to market, 2) enjoys lowered electrical and heating costs, 3) enjoys full employment, and 4) benefits from energy security.
| **Senvion**<br>**(formerly RE Power)** | Senvion manufactures large industrial scale wind turbine generators. The company is headquartered in Hamburg but our group visited its Husum plant which is the original manufacturing plant and test center site for the Senvion group. Perhaps best known for producing a monstrous 6.2MW turbine with a rotor diameter of 152m primarily designed for offshore use, Senvion also manufactures the REpower MM92, a commonly used turbine in the United States. |
Appendix C: Pre- and Post-Travel Survey Results

Instrument questions *(responses were free write)*

1. What do you know about the similarities and differences between the American and German education system at the secondary level?

2. What do you know about the similarities and differences between the American education system and the German education system at the postsecondary level?

3. What do you know about the various credentialing methods in the renewable energy fields in Germany?

4. What do you understand about workforce development programs in Germany?

5. What is your knowledge concerning the relationship between education and renewable energy workforce development in Germany?

6. What do you understand about German governmental policy and how it interacts with workforce capacity building in Germany in regards to renewable energy?

Pre-survey responses

On questions 1 and 2, five respondents indicated a small bit of knowledge or proposed what they expected to find. 7 of the 12 respondents on both questions indicated no knowledge.

For questions 3, 4 and 5, all respondents indicated little to no knowledge in these areas. “Nothing” or “I have no knowledge at this time” were common responses.

On question 6, respondents indicated some awareness of the Energiewende or at least the green energy policy initiatives of the German government mostly in the areas of economic incentives. Still, 5 of the 13 respondents replied again with “nothing”.

Post-survey responses

Answers to questions 1 and 2 provided details, comparisons and contrasts between the US and German education systems and technician training options. The responses were far less speculative and much more fact-based.

Seven of the twelve responses to questions 3 outlined the “credentials” offered by not-for-profit training agencies, with three describing the programs in detail. Five respondents indicated a desire to have learned more about how industry views these non-traditional
credentials. Eight respondents indicated that they were not sure but felt that non-degree certification was not an option in traditional schooling settings.

For questions 4 and 5, nine of twelve responses described and lauded the “dual system” that combines workplace and school-based learning as critical in the development of Germany’s technician workforce. The other three provided details on the for-profit training centers and their part in preparing technicians for market. Many comments were made concerning the tight integration between industry and education with nine respondents particularly noting the established collaboration between these sectors in developing, funding and shaping formal training programs.

Responses to question 6 on the post-travel survey demonstrated less of a dramatic knowledge gain than other questions but were much more detailed, contained less speculation and used more facts to support statements than in the pre-travel survey. Examples of how governmental policy shapes and supports workforce development were offered by eight of the twelve respondents.
### Appendix D: Sector Report Key Findings

<table>
<thead>
<tr>
<th>Sector</th>
<th>Key Findings</th>
<th>Recommendations</th>
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<tbody>
<tr>
<td>Biofuel</td>
<td>Germany is mostly focused on production of biodiesel from oilseed crops, whereas in the U.S. we have focused on production of ethanol from corn. The liquid biofuels in the US seems to have one fundamental advantage over German biofuels: an abundance of agricultural land.</td>
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<td>The biggest difference between US and Germany in biofuels sector is the feed-in tariff incentives (FIT) that reward BioEnergy project developers for producing and selling electricity, offering them better profit margins than they could achieve in the liquid transportation fuel market. Since there is no additional value for bio-electrons in the US, most biogas operations are built for odor control and waste management purposes.</td>
<td>The addition of feed-in tariffs (FIT) could have a dramatic impact by adding additional financial incentive for farmers to generate energy from their animal waste.</td>
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<td>It appears that industry involvement in German training programs is imperative to making their system work. Because students are going to school and doing apprenticeships at the same time, the only way the system works is for industry involvement.</td>
<td>Legacy training programs in traditional fields can support and train students who are interested in working in renewable energy, while at the same time offering larger employment potential and much broader connections with industry.</td>
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<td>The most telling point about biofuels education and training in Germany was that there really didn’t seem to be any. Instead it seems Germany is filling this need with training from other sectors. In contrast there seems to be a desire in the US for schools to have dedicated biofuels training programs.</td>
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German education is fully funded by the government. The German logic seems to be that by educating more people, their economy as a whole will be stronger and will generate more revenue. By contrast, in the U.S. the current “conventional wisdom” seems to be that education is primarily an individual benefit, and thus the student should be responsible for self-financing their education.

**Education Policy**

Germany’s national policy of education-industry-trade union collaboration and consensus has been a great benefit in workforce development for the technical programs. Industry has a much bigger role in education in Germany with companies and labor unions having a major say in the curriculum and students working as part of their training. While some educational institutions in the U.S. have established partnerships with industry, this is not compulsory, and the direct involvement of trade unions is mostly missing.

There is some uncertainty about job prospects for graduates in both countries because of government policy and planning. Germany’s renewable sectors are highly subsidized, mostly through feed-in tariffs that are guaranteed for 20 years after completion of an installation. However, such tariffs are proposed to be scaled back as sectors approach national goals for energy production; this will influence the need for workers. In the U.S., renewable sectors have been granted tax credits and some smaller feed-in tariffs, however these are usually short-term and subject to

Create stronger, formal, explicit, and collaborative relationships between education, industry and the trade unions to support the development of curriculum, internships and employment pathways for students.

A predictable policy on renewable energy as well as a sound and long-term plan for sector development would favorably influence the development and strength of education in these sectors.

It is increasing thought that a student should be broadly educated in a technology (for example, electronics, mechatronics, electrician trades) with specialized training in one or more energy fields (for example, wind or solar installations.)
Building Efficiency

Through broad adoption of PassivHaus standards and similar trending codes and standards, Germans incorporate efficiencies into the built environment in ways not often seen in the US.

When overly warm, the only option for U.S. commercial building occupants is to manage the thermostat and the unseen, energy-intensive chiller plant. In striking contrast, our German hosts dressed for the temperature, were likely to open a window if needed, and appeared to be disinclined to call for air conditioning or mechanical ventilation.

Germany’s dual system of vocational education and training (VET) has been a major factor in Germany’s economic success and inventiveness over the past six decades. The holistic approach and its high quality, and first-class reputation have made the German dual system itself an export success, too.

In the U.S., building technician education and training must improve rapidly to create and sustain energy efficiency improvements.

A culture shift is necessary if the U.S. is to achieve even partial gains in terms of reduced energy consumption. But how to you get people to open windows and keep unnecessary lights turned off?

While possibly unachievable, it would be wonderful if U.S. technician education programs could be allowed to collaborate in a sustained and long-term manner with both industry and with the labor unions.

Geothermal

Compared to the U.S., Germany’s geothermal power capacity is still in its infancy. While the U.S. has almost 3500 MW, Germany’s current geothermal power capacity is only 23.3 MW as of the end of 2013. Nonetheless, Germany is committed to expanding its geothermal power base by promoting an attractive feed-in tariff of 25 Euro cents per kilowatt hour for 20 years.

Managers of geothermal power plants look to hire students trained mainly in industrial maintenance. Any specific training peculiar to the operation of a

The larger area for student training in geothermal for both countries may lie in the area of geothermal heat pumps. Here students would learn the fundamentals of geothermal heat pumps as a component in HVAC (heating, ventilation, and air conditioning) training.

Embracing a long-term view when making economic decisions in the areas of renewable energy or climate change would allow for workforce education planning and the growth of jobs.
geothermal power plant would be learned on site.

Industry has a large role in promoting education and training programs in Germany. This stands in contrast to the U.S., where industry plays a limited role in the higher education and training of workers both in terms of funding and input concerning skills needed. Many of the businesses offer paid apprenticeships while students are in school.

The energy sector and government policymakers in Germany appear to take a long view; this, in turn, provides greater support for workforce education planning. Many of the decisions made by industry and government in the U.S. – including those that involve renewable energy and climate change - are based on market forces, which are notoriously short term and disinterested in long-term implications. This undermines many things including any kind of predictable planning for workforce education or needs.

<table>
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<tr>
<th>Energy Policy</th>
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| The share of electricity produced from renewable energy in Germany has increased from 6.3 percent of the national total in 2000 to about 25 percent in the first half of 2012. Also, some 370,000 people in Germany were employed in the renewable energy sector in 2010, which represents an increase of around 8 percent from 2009 and well over twice the number of jobs in 2004.

As a downside, feed-in tariffs are financed by a surcharge paid by utility customers, but industry is largely exempt from the renewables surcharge.

It is vital that colleges actively engage with their local companies and perform regular labor market/demand studies to ensure that there are jobs available for graduates. The worst thing a college can do is to prepare a student for a career field in which there are no jobs. When there ARE jobs, the colleges need to work with industry to constantly upgrade their curricula to make sure it meets the demands of business and industry so they hire our graduates. |
meaning the burden falls on households. There is legislation attempting to correct this.

The transition to renewables includes completely phasing out nuclear power which traditionally has provided much of Germany’s base load power demands. This is only achievable in combination with greatly reduced energy demand which is still underway. As a result, coal imports are increasing in order to meet the country’s needs. And retail electricity rates are high and rising, putting pressure on lower income individuals in particular.

Unlike Germany, the US does not have an energy transition plan to move to renewable energy but passes separate bills on specific energy issues.

**Solar**

The major factor in deciding to use solar electricity, and to what extent, is the cost of traditional (primarily fossil) fuels. In the US fossil fuels are inexpensive in comparison to solar, where in Germany it is quite the opposite. Using costs as the primary factor in energy decisions, as we do, is simplistic since these costs often do not include environmental damage, nor account for the fossil fuel reserves that are being depleted. Germany is factoring all of these concerns, but has yet to find a clean energy that can offset this.

There are no permitting/installation requirements for solar installations in Germany! The only requirement is that a licensed electrician make the connection of the solar system to the grid. Thus, residential solar installations in the US are considerably more expensive than Germany, even

It increasingly appears that it is not necessary to create specialized niche programs in this area. The businesses and the students are better served when the programs are based on a solid foundation of electro-mechanical courses.

A national and coordinated renewable energy plan and accompanying policies could increase jobs, the environment, and move our country into the future.

Involving industry in a centralized manner, such as an accrediting authority or required partner, solves some of the issues related to numerous community colleges pulling people from the same industry in many directions. This may be a good starting point for increasing industry influence on technician training programs.

There is a huge opportunity for the US to embed renewable energy concepts into existing technician training programs as has Germany.

It would be beneficial for the U.S. to assess its current resources, assess its future needs, project its current replacement energies (in Germany's case, renewables), visualize its future energy distribution systems, and try to
though German installers are paid more per hour. This higher cost of approximately 30% is related to permitting and code requirements. These higher costs of have an impact on the financial feasibility of these systems, and slow the market.

Renewable energy training is embedded across the general curriculum; this is a critical concept. This means that all electricians learn photovoltaic, all plumbers learn solar heating, all language students learn renewable energy policy and related events. Solar technology is not stand-alone but an integral part of the trade training.

Without a holistic and long-range view of the whole energy picture, the small but necessary and continuous steps that lead to whole-scale change will not appear.

We believe that there are benefits to an increased emphasis on energy education at all levels of society in the US much like we see in Germany today. An example of this was our visit to the English class at BSGG where the topic of (English-based) discussion was energy. It is through this cross-disciplinary education that an individual can begin to understand the role of energy across society.

Redefining specialized training

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<th>Wind</th>
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<td>Both the United States and Germany have private profit-based organizations and public schools offering training applicable to wind turbine maintenance technicians. The public schools in both countries seem to have come to the realization that wind turbine training programs are better classified as industrial maintenance training programs with special case work at height scenarios. Also, a number of schools have refocused their efforts on traditional electrical engineering technician programs. Those individuals graduating from these programs are still</td>
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foresee any negative consequences. This would directly benefit the populace but also allow for education to predict needs and plan accordingly.
viable candidates for employment in the wind industry as well as other careers.

Both the United States and Germany wind industries seem to be heavily dependent upon government involvement to initiate development with the principal difference being the consistency of incentives and the long-term stability of financial conditions. The United States production tax credit is largely a fleeting program that may or may not be renewed pending upon the political environment from one year to the next. The German Energiewende, in contrast, expressly considers the yearly expansion of wind power to be one of its principal enablers. This long-term plan creates a stable and predictable renewable energy market.

Any program that does not actively pursue a high level of industry involvement will quickly become irrelevant. Learning from how the German education system fosters industry involvement is key for improving American systems for such collaboration.

Long-term, sustained and predictable incentives for renewable energy (including wind power) can stabilize production, jobs and, consequently, education program planning and effectiveness.