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A National Skills Assessment of the U.S. Wind Industry in 2012

M. Leventhal and S. Tegen

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Technical Report
NREL/TP-7A30-57512
June 2013

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Prepared under Task No. WE11.0610

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List of Tables

Introduction

A robust and well-trained workforce is essential to developing domestic wind power projects to meet future energy demands. The future wind power workforce will include manufacturing, siting, operations, maintenance, education, and research capabilities. How prepared is the United States to train future employees in the wind industry? The purpose of this research is to better understand:

- Today's domestic wind workforce
- Projected future workforce needs
- Whether existing and new training and educational programs meet the wind industry's future needs.

Results presented in this report provide the first published investigation into the detailed makeup of the wind energy workforce as well as a glance at the educational infrastructure and training needs of the wind industry. Insights from this research into the domestic wind workforce will allow the private sector, educational institutions, and federal and state governmental organizations to make better informed workforce-related decisions based on the current data and future projections.

Methods

After completing a literature review of publicly available reports, National Renewable Energy Laboratory (NREL) researchers learned that a U.S. wind workforce or labor assessment had not been performed on a national scale. The U.S. Department of Energy (DOE) funded NREL to assess the existing wind workforce with an emphasis on skills and training. Using projections from the report *20% Wind Energy by 2030: Increasing Wind Energy's Contribution to U.S. Electricity Supply* (U.S. DOE 2008; hereafter referred to as 20% Wind by 2030), we estimated future industry needs and will compare them to existing wind training programs. This enables NREL to provide information to DOE about whether the United States needs to increase the number of educators and students attending wind training programs to meet wind deployment goals.

Our research had five components:

1) Conduct a wind industry employer survey

2) Compile an evolving catalog of wind-specific education and training programs

3) Correlate employer preferences with available education and training programs

4) Project new hires needed in the wind workforce to account for growth needed for the 20% Wind by 2030 scenario

5) Estimate the number of graduates needed by program type (e.g., graduate-level course, community college degree).

The following sections describe the methods used for each of these components.

Conduct Wind Industry Employer Survey

The first component of our research was a wind industry employer survey to better understand the size of the domestic wind workforce and the distribution of occupations across the wind industry supply chain, as well as to assess the level and types of education, training, and experience preferred by employers when making hiring decisions.

To conduct the survey, NREL hired BW Research Partnership, a firm experienced in workforce surveys and analyses. Survey data were collected in August and September 2012. Employers first received the survey via e-mail. BW Research initiated a phone survey for employers who did not respond online. Appendix D of this report contains the full survey questionnaire

The total survey size consisted of approximately 1,900 contacts from the commercial-scale wind energy industry, and we received 418 completed responses. Industry contacts for the survey came from various sources, including the membership lists of the American Wind Energy Association (AWEA) and Windustry, and contacts within NREL's OpenEI and Wind Powering America contact databases.[1]

The detailed questions for employers concerning each occupation included:

- Level of difficulty in finding qualified applicants (by occupation)
- Importance of occupational experience versus wind-specific experience
- Preferred educational attainment for new hires
- Employers' preferences for wind energy training and education
- Importance of wind energy college degrees versus degrees not related to wind energy
- Female representation in the wind energy workforce by occupation.

The questionnaire included 35 occupations divided among 15 wind industry company classifications, such as project development, turbine manufacturing, installation, and operation (see Table 1). These occupations and wind industry company classifications were developed by several NREL employees, each with extensive wind energy experience, specifically for this survey. Suitable Bureau of Labor Statistics Standard Occupational Classification codes do not currently exist for the full breadth of occupations within wind energy and thus could not be used.

The 35 occupations were selected from a larger list of wind industry jobs (the fewer number of occupations allows focus while still demonstrating the wide diversity of occupations across the industry). Several occupations (e.g., administrative or clerical) existed in more than one wind industry classification. The questionnaire asked employers to select a primary industry classification for their company (from a list of 15) and then asked them to select which occupational categories best represent their employees (from a list of 5 to 8). Of course, many companies employ more than five to eight occupations, so our list was not exhaustive and instead focused on the most prevalent wind occupations within that industry classification.

[1] http://en.openei.org/wiki/Main_Page and http://www.windpoweringamerica.gov

To maximize response rates and minimize the number of incomplete surveys, questions and response options were structured to allow respondents to complete the survey within a 15-minute timeframe. This is a standard threshold to minimize fatigue and dropout (Jordan 2012). For instance, if an employer noted that his company employed all eight occupations listed for his industry classification, detailed questions of only four of these occupations, chosen randomly, would be asked of this employer. Table 1 shows which occupations were included in each industry classification. The green boxes indicate that the occupation was present in the industry classification.

Table 1. Industry Classification and Occupations

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Occupations Included Per Supply Chain Classification in Wind Employer Survey	Site Identification, Assessment, or Pre-Development	Project Development: Legal, Real Estate, or Finance	Project Permitting: Regulatory, Environmental, or Wildlife Assessment	Manufacturing of Engineered Structures (tower, bedplate, hub)	Manufacturing of Drive Trains (couplings, bearings, gearboxes)	Manufacturing of Blades	Manufacturing of Power Equipment and Electronics (generators, cables, cooling, lighting, etc.)	Manufacturing of Sub-Components or Materials	Nacelle Assembly	Sales, Distribution, or Transport of Wind Energy Products (including OEM sales)	On-site Civil Works (roads, foundations, site improvements)	On-site Mechanical Assembly (installation of towers or turbines)	On-site Electrical Work (substation, collection grid, final grid connection)	Operations and Maintenance	Education, Training, or Research
Admin/clerical	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Assembly workers							■		■						
Attorneys		■								■				■	
Construction laborers											■	■	■		
Construction managers											■	■	■		
Development finance		■													
Development managers		■													
Development technical specialists		■													
Engineers	■	■	■							■	■	■	■	■	
Government regulatory workers			■												
Land-leasing agents		■													
Managers of sales, operations, & training										■				■	■
Manufacturing managers				■	■	■	■	■	■						
Manufacturing salespeople				■	■	■	■	■	■	■					
O&M accountants & bookkeepers														■	
Paralegals		■													
Product designers				■	■	■	■	■	■						
Professional trainers															■
Professors & teachers															■
Research engineers															■
Resource assessors & surveyors	■										■				
Scientists	■		■												
Supply chain & purchasing managers				■	■	■	■	■	■						
Trade workers				■	■	■	■	■	■		■	■	■		
Transportation/logistics workers										■					
Wind technicians												■		■	

*Industry classifications are listed in columns; occupations are listed in rows

After data collection, we aggregated jobs within similar occupational categories to minimize redundancy and adjusted occupation names for clarity as needed. We also deleted one occupational role as only two companies claimed to employ that position. In the end, we performed our full analysis on 26 occupations in the wind industry.

Table 2. Occupations Included in the Report

	# of Firms Responding with this Occupation
Admin/clerical	131
Managers of sales, operations, & training	88
Engineers	65
Trade workers	58
Supply chain & purchasing managers	52
Manufacturing managers	43
Product designers	40
Manufacturing salespeople	39
Professors & teachers	37
Attorneys	34
Research engineers	32
Professional trainers	30
Development managers	27
Construction managers	25
Scientists	21
Development finance	20
Development technical specialists	19
Construction laborers	15
O&M accountants & bookkeepers	15
Wind technicians	14
Land-leasing agents	13
Resource assessors & surveyors	18
Government regulatory workers	11
Transportation/logistics workers	17
Paralegals	9
Assembly workers	9

Catalog Wind-Specific Education and Training Programs

The second component of this study was to catalog available wind-specific education and training programs to learn about the number of graduates and percentages of graduates working in the wind industry.

We conducted the cataloging by searching post-secondary schools' and educational organizations' websites to identify wind-specific programs in the United States. We searched websites of schools previously identified by Wind Powering America as having some association to wind energy education. We documented classes, degrees, research, and major resources (e.g., a working wind turbine that could be utilized for training). We categorized degrees as Certificate, Associate's, Bachelor's, Master's, and Ph.D. The catalog only includes information on programs focusing on wind energy or renewable energy with a large portion of the curriculum devoted to wind. The program title or description must include the word "wind" or "renewable."

After we cataloged a school's programs, we sent an e-mail to professors and administrators asking them to 1) review the school's publicly available program descriptions for completeness and accuracy, 2) enumerate how many people graduated from each program, and of those, 3) identify what portion proceeded to work in the wind industry, if known. NREL researchers aggregated the responses from these schools to create a dataset of wind-specific education and training programs. An example is shown in Table 3. This example shows a single degree program from a single school; many schools offer multiple programs.

Table 3. Sample Educational Program

Type of School	School Name	Extent of Wind Focus (Credential, Courses, Research, Resource)	Program (Ph.D., Master's, Bachelor's, Associate's, Certificate)	Name of Program/ Concentration	Graduates per Year	Number Entering Wind Industry	Percent Entering Wind Industry
Universities	University of Your State	Credential	Master's	Graduate Program in Renewable Energy Development	10	3	30%

Correlate Employer Preferences with Available Education and Training Programs

The next phase involved connecting employers' preferences regarding education level attained for each occupation with wind-specific programs that meet those preferences. To achieve this, we focused on two questions from our employer survey.

- Q7: preferred educational attainment for new hires
- Q8: the importance of wind-specific experience, certification, and education vs. occupational-focused education that is not specific to wind.

In the example in Table 4, we see that employers most frequently preferred a graduate-level education for research engineers. However, some employers only required a bachelor degree, while some wanted a post-bachelor professional certification. We utilized the full range of employer responses in our analysis.

Table 4. Example of Employer Educational Preference for an Occupation

	High School Diploma	Post-Secondary Professional Certificate (Journeyman, Trade/Technical Programs)	Associate's Degree	Bachelor's Degree	Post-Bachelor Professional Certification (e.g., CPA, PE, LEED)	Master's Degree, Ph.D., or Law
Research engineers	0%	0%	0%	17%	11%	71%

We also need to understand whether employers require this degree to be *wind-specific* because one focus of this research is whether enough *wind-specific* training and educational programs are available. To achieve this, we examined the ratio of employers preferring wind-specific college degrees to degrees not focused on wind (or for the few occupations that do not require some type of college degree, we look at a similar ratio concerning professional certification). Table 5 shows the percentage of employers indicating that they felt it was "very" or "somewhat" important for employees in this particular occupation to have the specific degree.

Table 5. Example of Relative Importance of Wind-Specific Degree

	College Degree	Wind-Specific College Degree	Ratio of Importance of Wind-Specific College Degree vs. Degree Not Specific to Wind
Research engineers	97%	48%	50%

In the case of research engineers, we found that approximately half as many employers rated a wind energy-specific degree as important relative to a general college degree. For our analysis, we multiply responses from Q7 (Table 4) by responses to Q8 (Table 5) to determine the percentage of wind-specific degrees that are needed by occupation, by degree level.

To determine whether the United States will have enough qualified employees to meet future labor needs of the wind industry, we need to answer such questions as:

- How many new employees in a given occupation will the wind industry require over the next 20 years?
- How many participants of qualifying programs will graduate each year?

The final two steps of the analysis enable us to begin to answer these questions.

Project New Wind Workforce Hires Needed for the 20% Wind by 2030 Scenario

The wind employer survey estimated that approximately 70,000 people are currently employed in the United States in the wind energy industry.[2] As construction continues each year and cumulative installed capacity increases, the U.S. wind industry will require more workers. By associating the current workforce with capacity installed[3] in 2012 (12 GW) and cumulative installed capacity (59 GW in 2012), we can estimate increases needed in the wind labor workforce to meet annual installation schedules described in DOE's 20% Wind by 2030 modeled energy scenario. Such a projection includes estimates for increases in production efficiency per worker, as well as attrition due to people leaving the industry to retire or pursue other careers. The authors understand that the scenario as represented in the 20% Wind by 2030 report is only one potential scenario that the wind industry could follow. Readers should consider projections in this report indicative of future industry needs, based on current workforce trends, assuming a strong future marketplace for wind energy development as outlined in the 2008 DOE report.

Estimate Number of Graduates Needed by Degree Type

After we estimate how many new employees we might need per occupation by year, we apply our calculated percentage requiring a wind-specific degree of a given level. This indicates how many graduates with wind-specific degrees are needed per year. By adjusting this figure by the likelihood of these graduates to enter the wind industry after graduation and how many students graduate from each program per year, we can develop an estimate of how many programs are needed at each degree level. Our analysis focuses on the needs of the peak hiring year for the industry (2016 for most occupations; 2019 for occupations in the operations and maintenance (O&M) sector). The results are estimates based on the data we obtained, which are limited by the small sample size of education and training programs.

Results

Wind Industry Employer Survey

As stated, NREL hired a contractor to conduct a wind industry employer survey for which we had approximately 1,900 contacts in the utility-scale wind energy industry.[4] We received 418 valid responses. Appendix C of this report contains the full survey questionnaire.

The following results are based on stated preferences of our sample of wind energy employers. While our total sample consisted of more than 400 employers, since these employers occupied different positions within the supply chain (and hence employed different occupations), any single occupation included responses with a base size of employers ranging from nine to 131. About half the occupations included responses from 30 or more employers.

Table 6 lists occupations ranked from high to low based on the percentage of companies citing "great difficulty" finding qualified applicants for a given occupation. Overall, wind employers were more likely to state they had "some difficulty" finding qualified applicants, as opposed to

[2] See Appendix D for an explanation of how we estimated the approximately 70,000 employees.
[3] 12 GW of capacity installed in 2012 was the estimated end of year figure as of November 2012. Actual installations came in slightly higher at 13 GW.
[4] Educational institutions were also included in the survey if they offered wind education programs.

"great difficulty." According to this survey, the most difficult positions to fill are professors and teachers.

Table 6. Level of Difficulty in Finding Qualified Applicants (by Occupation)

	Some Difficulty	Great Difficulty	Some or Great Difficulty
Professors & teachers	41%	43%	84%
Product designers	40%	35%	75%
Trade workers	40%	31%	71%
Manufacturing salespeople	33%	31%	64%
Wind technicians	50%	29%	79%
Construction managers	44%	28%	72%
Professional trainers	50%	27%	77%
Development technical specialists	47%	26%	74%
Engineers	42%	25%	66%
Scientists	48%	24%	71%
Research engineers	47%	22%	69%
Managers of sales, operations, & training	40%	22%	61%
Attorneys	26%	18%	44%
Transportation/logistics workers	24%	18%	41%
Land-leasing agents	31%	15%	46%
Development managers	37%	15%	52%
Paralegals	33%	11%	44%
Supply chain & purchasing managers	44%	10%	54%
Construction laborers	67%	7%	73%
Resource assessors & surveyors	39%	6%	44%
Development finance	35%	5%	40%
Admin/clerical	31%	4%	35%
Manufacturing managers	72%	2%	74%
Government regulatory workers	73%	0%	73%
O&M accountants & bookkeepers	60%	0%	60%
Assembly workers	67%	0%	67%
Average	**45%**	**17%**	**62%**

Response scale:	No Difficulty	Some Difficulty	Great Difficulty

Table 7 compares employers' preferences for new hires with wind-specific work experience relative to general occupational experience. The data are ranked by the ratio of importance of each of these types of work experience. Across all occupations, wind employers agreed that it was more important that new hires have experience in their occupational field over wind-specific experience. Those roles near the top of the table represent the positions for which wind industry experience requirements are almost as important as general experience in the occupation.

Table 7. Work Experience: Importance of Occupational Experience vs. Wind-Specific Experience

	Importance of Work Experience when Hiring Employees (Mean Rating)		
	Experience in a Related Occupational Field	Experience in Wind Energy	Ratio (Wind Specific/Related Occupation)
Resource assessors & surveyors	1.9	1.8	94%
Professional trainers	2.6	2.4	93%
Managers of sales, operations, & training	2.3	2.1	91%
Research engineers	2.5	2.2	90%
Professors & teachers	2.6	2.3	87%
Engineers	2.3	2.0	87%
Construction managers	2.6	2.2	84%
Development technical specialists	2.7	2.3	83%
Development managers	2.8	2.3	83%
Transportation/logistics workers	2.3	1.9	82%
Construction laborers	2.0	1.6	82%
Assembly workers	2.3	1.9	81%
Manufacturing salespeople	2.2	1.8	79%
Wind technicians	2.5	1.9	78%
Admin/clerical	1.8	1.2	71%
Development finance	2.2	1.5	70%
Scientists	2.4	1.7	69%
Product designers	2.4	1.7	68%
Attorneys	2.2	1.5	66%
Land-leasing agents	2.4	1.6	66%
Trade workers	2.3	1.5	64%
Paralegals	1.8	1.2	64%
Manufacturing managers	2.4	1.4	61%
Supply chain & purchasing managers	2.2	1.4	61%
O&M accountants & bookkeepers	2.3	1.1	50%
Government regulatory workers	2.5	1.0	40%
Average	**2.3**	**1.7**	**75%**
Response scale:	Not Needed +1	Somewhat Important +2	Very Important +3

Table 8. Preferred Educational Attainments for New Hires

	High School Diploma or Less	Post-Secondary Professional Certificate (Journeyman, Trade/ Technical Programs)	Associate's Degree	Bachelor's Degree	Post-Bachelor Professional Certification (e.g., CPA, PE, LEED)	Master's Degree, Ph.D., or Law
Attorneys	0%	0%	0%	6%	21%	74%
Research engineers	0%	0%	0%	17%	11%	71%
Scientists	0%	0%	0%	19%	10%	71%
Government regulatory workers	0%	0%	0%	42%	0%	58%
Professors & teachers	0%	5%	15%	10%	7%	63%
Development managers	0%	3%	0%	39%	29%	29%
Engineers	0%	2%	0%	54%	15%	29%
Managers of sales, operations, & training	1%	2%	5%	42%	16%	34%
Development finance	0%	0%	5%	50%	23%	23%
Development technical specialists	5%	5%	0%	47%	11%	32%
Product designers	3%	3%	0%	63%	10%	23%
Resource assessors & surveyors	6%	6%	22%	33%	0%	33%
Professional trainers	3%	16%	10%	32%	10%	29%
O&M accountants & bookkeepers	7%	0%	13%	60%	13%	7%
Manufacturing salespeople	3%	3%	10%	79%	3%	3%
Construction managers	4%	12%	8%	58%	12%	8%
Manufacturing managers	2%	9%	13%	69%	7%	0%
Supply chain & purchasing managers	2%	4%	25%	68%	2%	0%
Paralegals	0%	0%	38%	63%	0%	0%
Land-leasing agents	0%	21%	7%	71%	0%	0%
Admin/clerical	18%	13%	28%	36%	1%	4%
Transportation/logistics workers	28%	11%	22%	33%	6%	0%
Trade workers	27%	62%	7%	5%	0%	0%
Wind technicians	25%	58%	17%	0%	0%	0%
Assembly workers	33%	44%	22%	0%	0%	0%
Construction laborers	56%	44%	0%	0%	0%	0%

In Table 8, occupations are ranked from high to low by required educational achievement (mean years; not directly shown in chart). The yellow highlighting represents the most common response per occupation. Wind industry employers require a wide range of educational levels for the different occupations they hire. The most common educational achievement required was a bachelor's degree; several occupations required an advanced degree. Employers preferred that trade workers, wind technicians, and assembly workers have some form of post-high school professional training and that construction workers have a high school diploma.

Table 9 compares the importance of three levels of wind energy-specific training by occupation:

- Courses, conferences, workshops
- Professional certification
- Wind energy-specific college degree.

The table is ranked high to low on the first column of data.

Yellow highlighted text represents 40% or more of wind employers rating wind energy-specific professional certification or a wind-specific college degree as "very or somewhat important." This applies to a minority of occupations. By comparing the average across the three, we see that wind employers desire their new hires to have been exposed to some basic level of wind energy training, but requirements for professional certification or wind-specific college degrees are not important for the majority of occupations in the wind industry.

Please note that wind energy-specific programs are recent developments. Thus, it is possible that employers not rating these programs as important may be due to the fact that until recently, few if any were available.

Table 9. Importance of Different Levels of Wind Energy Training and Education

% Rating "Very or Somewhat Important"	Wind Energy-Specific Training (Including Courses, Workshops, Conferences, Etc.)	Wind Energy-Specific Professional Certification	Wind Energy-Specific College Degree
Professional trainers	87%	57%	22%
Research engineers	86%	55%	48%
Professors & teachers	86%	56%	47%
Development technical specialists	84%	63%	47%
Development managers	78%	28%	28%
Construction managers	68%	36%	18%
Managers of sales, operations, & training	67%	31%	24%
Resource assessors & surveyors	65%	18%	24%
Wind technicians	60%	47%	40%
Engineers	58%	44%	36%
Manufacturing salespeople	57%	11%	11%
Assembly workers	57%	43%	29%
Product designers	56%	26%	15%
Scientists	53%	27%	20%
Attorneys	48%	3%	7%
Land-leasing agents	46%	8%	15%
Construction laborers	45%	0%	0%
Manufacturing managers	43%	20%	10%
Development finance	35%	5%	5%
Government regulatory workers	33%	0%	0%
Paralegals	33%	17%	17%
Trade workers	33%	21%	7%
Supply chain & purchasing managers	24%	12%	6%
Transportation/logistics workers	20%	0%	13%
Admin/clerical	19%	10%	8%
O&M accountants & bookkeepers	14%	0%	7%
Average	**52%**	**24%**	**19%**

Response scale:	Not Needed	Somewhat Important	Very Important

Table 10 compares the relative importance of a wind-specific college degree to that of a college degree that is not specifically focused on wind energy. The table is ranked high to low on this ratio, which is shown in the far right column. With the exception of a few occupations, only a minority of employers required college degrees specific to wind energy. All employers requiring wind technicians and assembly workers to hold a college degree felt that it is important that the degree is specific to wind energy. Approximately half of wind employers claimed that it was important for new hires to have a wind-specific degree in the occupations of development technical specialists, research engineers, and professors/teachers.

Table 10. Importance of Wind Energy College Degrees vs. Degrees Not Related to Wind Energy

% Rating "Very" or "Somewhat" Important	College Degree	Wind Energy-Specific College Degree	Ratio of Importance of Wind Energy-Specific College Degree vs. Degree Not Specific to Wind
Assembly workers	29%	29%	100%
Wind technicians	40%	40%	100%
Development technical specialists	84%	47%	56%
Research engineers	97%	48%	50%
Professors & teachers	100%	47%	47%
Trade workers	19%	7%	38%
Engineers	100%	36%	36%
Development managers	94%	28%	30%
Resource assessors & surveyors	88%	24%	27%
Managers of sales, operations, & training	95%	24%	25%
Transportation/logistics workers	53%	13%	25%
Land-leasing agents	62%	15%	25%
Professional trainers	91%	22%	24%
Construction managers	77%	18%	24%
Scientists	100%	20%	20%
Paralegals	100%	17%	17%
Product designers	93%	15%	16%
Manufacturing salespeople	86%	11%	13%
Admin/clerical	61%	8%	13%
Manufacturing managers	80%	10%	13%
O&M accountants & bookkeepers	93%	7%	8%
Supply chain & purchasing managers	79%	6%	7%
Attorneys	100%	7%	7%
Development finance	85%	5%	6%
Construction laborers	9%	0%	0%
Government regulatory workers	100%	0%	0%
Average	**77%**	**19%**	**28%**

Response scale:	Not Needed	Somewhat Important	Very Important

Table 11 exhibits the percentage of female wind employees by occupation. Employers' responses indicate that the vast majority of paralegals, administrative staff, and government regulatory workers in the wind industry are female (more than 80%). The majority of O&M accountants/bookkeepers, supply chain/purchasing managers, and development finance employees are women. Women made up less than 20% of employees in 12 of the 26 occupations studied during this research.

Responses to survey questions asking about minority representation (including women) tend to overstate the number of minorities in a business if that minority is a protected class of worker (Jordan 2012).

Table 11. Female Representation in Wind Energy Workforce by Occupation

	% Female by Occupation in Wind Energy Industry
Paralegals	More than 90%
Admin/clerical	More than 90%
Government regulatory workers	80%-89%
O&M accountants & bookkeepers	60%-69%
Supply chain & purchasing managers	50%-59%
Development finance	50%-59%
Scientists	40%-49%
Manufacturing managers	30%-39%
Attorneys	30%-39%
Land-leasing agents	30%-39%
Managers of sales, operations, & training	20%-29%
Professional trainers	20%-29%
Professors & teachers	20%-29%
Development managers	20%-29%
Research engineers	10%-19%
Development technical specialists	10%-19%
Construction managers	10%-19%
Resource assessors & surveyors	10%-19%
Engineers	10%-19%
Product designers	10%-19%
Trade workers	10%-19%
Manufacturing salespeople	10%-19%
Assembly workers	Less than 10%
Construction laborers	Less than 10%
Transportation/logistics workers	Less than 10%
Wind technicians	Less than 10%

Cataloging Wind-Specific Education and Training Programs

The table below summarizes the number of schools we contacted, how many responded, and of the responses, how many were completed thoroughly enough to use in our analysis. Eighteen schools provided complete information.

Table 12. Response Rate (Number of Schools)

E-mails sent	49		
Responses returned	31	63% of mail sent	
Quality data	18	58% of responses	37% of mail sent

Many schools offered multiple degrees. Of the 18 schools that provided thorough feedback, on average we received data for two to three programs per school. Thus, respondents provided information about 43 programs. The distribution of programs across degree levels is shown in Table 13.

Table 13. Distribution of Degree Program Levels in Response Set

Program Count	
8	Post-secondary certificate
10	Associate's degree
4	Undergraduate certificate
8	Bachelor's degree
1	Graduate certificate
8	Master's degree
4	Ph.D.
43	**Total**

Of the 43 programs, 18 are at the community or technical college level and 25 are university programs.

Table 14 lists summary statistics about post-secondary wind-specific educational programs and their graduates. The mean number of graduates per year from university programs is almost three times the median, indicating a strong skew generated by a few large programs in this sampling.

Results show that the percentage of community or technical college graduates who move into the wind industry after graduation is significantly higher than that of university graduates. This is likely due to the fact that 1- and 2-year technical programs offered by community colleges are tailored toward careers in wind energy more than higher-level degrees. Even though we attempted to focus our efforts on wind-specific degrees in university programs, many of these programs included wind energy content in addition to content on other renewables such as solar. These programs also included broad engineering disciplines utilized across a wide range of industries, including aerospace, utilities, and civil construction. Thus, the lower percentage of graduates entering the wind energy field from university programs may be due to a wider variety of opportunities available to these graduates.

Table 14. Graduates per Year and Percentage Entering Wind Industry

		Graduates per Year				% Entering Wind Energy Industry			
Program Count	Institution Type	Max	Mean	Median	Min	Max	Mean	Median	Min
18	Community & tech colleges	60	17	10	1	100%	75%	90%	0%
25	University	300	34	12	3	50%	15%	10%	0%

The much lower percentages of university graduates entering the wind industry compared to 1- and 2-year programs are due in part to the fact that university-level wind programs are not as narrowly focused on wind energy and also often include other renewable technologies such as solar and other specialties such as aerospace and civil construction.

Summary of Employer Educational Preferences

We derived Table 15 by combining employer survey responses to questions #7 and #8 in the questionnaire. [5] We examined the percentage of employers rating a wind energy-specific degree/certification as somewhat or very important in their hiring criteria, relative to a college degree/certification that is not wind-specific. We multiplied these ratios (importance of wind energy-specific versus a more general focus) by the preferred educational attainment for new hires by occupation. The resulting data reveal the percentage of new hires that should have a wind-specific degree or certification by occupation to meet employers' preferences.

Table 15 should be read across rows. For instance, these data indicate that 45% of employers prefer that a newly hired wind technician have a wind energy-specific professional certificate, while 17% want a wind-specific associate's degree. One can infer from this that 38% [100%-(45%+17%)] do not consider it important for their new wind technicians to have wind-specific education of this level. For example, perhaps the employer is willing to hire and train a new employee for this role if the new hire has experience in a relevant line of work.

[5] Q7: preferred educational attainment for new hires; Q8: the importance of wind-specific experience, certification, and education vs. occupational-focused education that is not specific to wind.

Table 15. Percentage of Employers Who Prefer a Wind Energy-Specific Degree/Certificate for New Hires by Occupation

	Post-Secondary Professional Certificate (Journeyman, Trade/Technical Programs)	Associate's Degree	Bachelor's Degree	Post-Bachelor's Professional Certification (e.g., CPA, PE, LEED)	Master's Degree, Ph.D., or Law
Admin/clerical	4%	4%	5%	0%	0%
Assembly workers	27%	22%	0%	0%	0%
Attorneys	0%	0%	0%	1%	5%
Construction laborers	0%	0%	0%	0%	0%
Construction managers	8%	2%	14%	3%	2%
Development finance	0%	0%	3%	1%	1%
Development managers	2%	0%	12%	9%	9%
Development technical specialists	4%	0%	27%	6%	18%
Engineers	1%	0%	19%	6%	11%
Government regulatory workers	0%	0%	0%	0%	0%
Land-leasing agents	4%	2%	18%	0%	0%
Managers of sales, operations, & training	1%	1%	11%	4%	9%
Manufacturing managers	3%	2%	9%	1%	0%
Manufacturing salespeople	1%	1%	11%	0%	0%
O&M accountants & bookkeepers	0%	1%	5%	1%	1%
Paralegals	0%	6%	10%	0%	0%
Product designers	1%	0%	10%	2%	4%
Professional trainers	12%	2%	8%	2%	7%
Professors & teachers	4%	7%	5%	3%	30%
Research engineers	0%	0%	9%	6%	36%
Resource assessors & surveyors	3%	6%	9%	0%	9%
Scientists	0%	0%	4%	2%	14%
Supply chain & purchasing managers	1%	2%	5%	0%	0%
Trade workers	25%	3%	2%	0%	0%
Transportation/logistics workers	0%	6%	8%	1%	0%
Wind technicians	45%	17%	0%	0%	0%

Project New Hires in Wind Workforce Needed for the 20% Wind by 2030 Scenario

To estimate new hires in the wind workforce, we began with our employer survey data, which served as a baseline of current wind industry employees as of August 2012, by occupation. Then we used the table below to project the future workforce. Most occupations were linked to annual gigawatts installed. For instance, the 20% Wind by 2030 scenario indicates that 14 GW of wind will need to be installed in 2016 (DOE 2008), 17% more than in 2012. Thus, we assume that some segments of the wind workforce need to expand by that percentage to meet the increase in installations, all else being equal.

However, all else is not equal each year. Our model also included two other factors: attrition at an average rate of 7% per year[6] and labor productivity increases of 1% to 3% annually, depending on occupation (Bloomberg 2012). Our attrition figure only accounts for retirement and individuals choosing to leave the wind industry and does not adjust for people who remain in the wind industry but move to a new company as that does not impact the number of new employees needed. As stated previously, 20% Wind by 2030 is only one industry growth scenario; if wind deployment continues above this amount, an expanded workforce would be expected. If deployment is slower than that represented in this scenario, a smaller workforce will be the likely outcome.

[6] Attrition figures are derived from the U.S. Bureau of Labor Statistics (accessed December 26, 2012: http://www.bls.gov/news.release/ecopro.htm).

Table 16. 20% Wind by 2030 Capacity Installation Requirements*

	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Annual GW Installed	12	5	10	12	14	15	16	16	16	16	16	16	16	16	16	16	15	14	13
Cumulative GW Installed End of Year	59	64	74	86	100	115	131	147	163	179	195	211	227	243	259	275	290	304	317
Average Cumulative GW Installed for the Year	53	62	69	80	93	108	123	139	155	171	187	203	219	235	251	267	283	297	311
Annual Capacity Installed Relative to 2012	1.00	0.42	0.83	1.00	1.17	1.25	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.33	1.25	1.17	1.08
Average Cumulative Installed Capacity Relative to 2012	1.00	1.16	1.30	1.51	1.75	2.03	2.32	2.62	2.92	3.23	3.53	3.83	4.13	4.43	4.74	5.04	5.33	5.60	5.86

*U.S. DOE 2008. Note: 2012 is likely to occur based on actual installations to date as of November 2012. 2013 is adjusted down based on DOE guidance due to recent industry expectations.

Jobs in the O&M sector were projected based on the growth of total cumulative installed capacity, not annual installations. The following jobs are found in the O&M sector in our survey:

Table 17. Percent of Selected Occupations from the Survey in the O&M Sector

Wind technicians	Primarily O&M	Greater than 70%
O&M accountants & bookkeepers	Significant O&M	Greater than 30%, less than 70%
Managers of sales, operations, & training	Significant O&M	Greater than 30%, less than 70%
Attorneys	Some O&M	Less than 30%
Admin/clerical	Some O&M	Less than 30%
Engineers	Some O&M	Less than 30%

These jobs are also found in other supply chain sectors, thus the relationship of their growth with increases in cumulative installations is correlated with the proportion of these jobs based in the O&M sector. Table 17 groups these occupations into Primarily O&M, Significant O&M, and Some O&M to clarify this relationship.

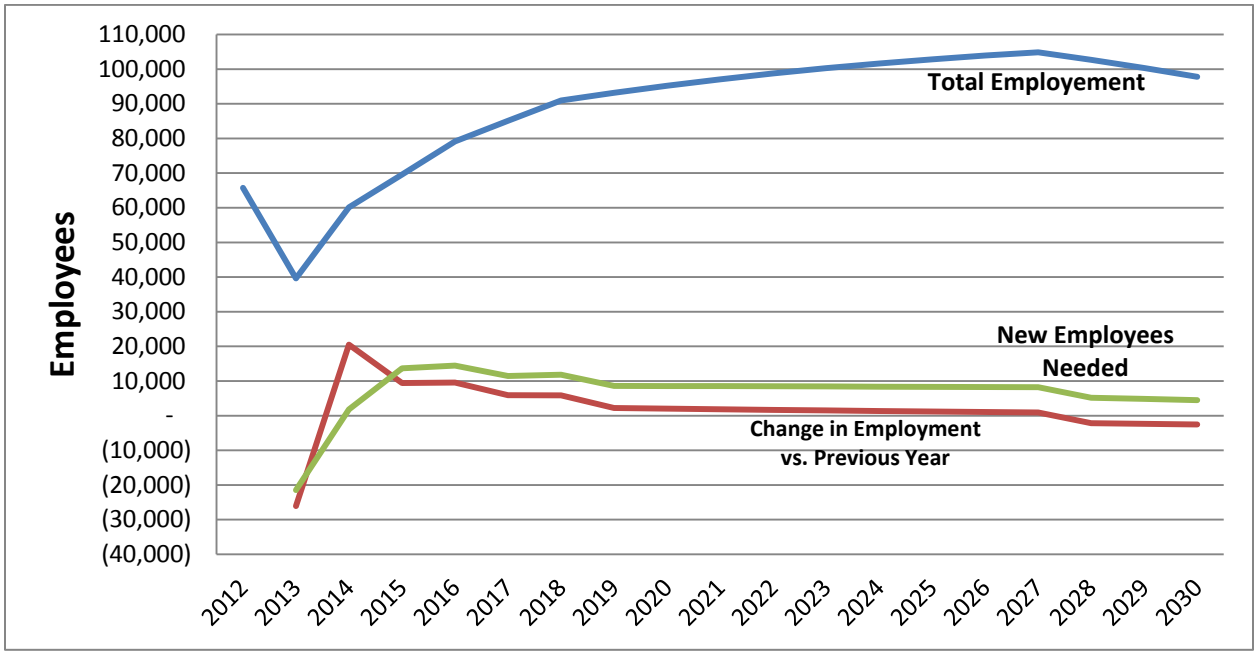

Figure 1. Wind employment projections to reach 20% Wind by 2030 (with average productivity increases of 2% and attrition of 7%)

The growth of the wind industry included in this report follows projections outlined in 20% Wind by 2030. This analysis did not attempt to assess whether these estimates of wind capacity installations were accurate or likely. We simply used these projections, with an adjustment to 2013 for the expected reduction in installations, to estimate the projected change in employment overall, as well as by occupation.

The wind industry is expecting a significant reduction in wind employment in 2013 because Congress did not renew the Production Tax Credit until January.[7] Based on projected installations of 5 GW in 2013, this analysis does not anticipate an increase in wind industry employment in the near term. In fact, reductions in workforce are likely to occur. Assuming a resolution of the issues leading to this expected decline by 2014 and continuance on the path outlined in the 20% Wind by 2030 scenario, most of those who lost their jobs in 2013 will be needed again, as well as almost 2,000 new employees. After that, 12,000 to 14,000 new employees per year will be needed from 2015 to 2018. From 2019 through 2027, 8,000 to 9,000 new employees will be needed per year. Total employment declines for the remaining 3 years should occur as projections for new installations in the 20% Wind by 2030 scenario begin to taper off. For these final 3 years, the new employees needed are primarily due to attrition replacement.

Table 18 breaks down our estimates of the number of new employees that will be needed by year and by occupation in the utility-scale wind sector. These estimates account for changes in capacity installed per year, attrition due to retirement and people choosing to leave the wind industry, and improvements in worker productivity. One can readily see that the largest demand is for wind technicians, as the number of technicians will continue to increase each year as the cumulative number of turbines installed in the United States grows. Further, many occupations are not accounted for in this research (see the last table row). Due to time constraints with our employer survey (to reduce respondent fatigue), we attempted to collect information on the most common occupations, but many job functions were not included.

Light blue boxes in Table 18 indicate that no new employees are needed for that occupation during that year (in fact, in 2013 it's expected that many employees will be dismissed). We assume that employees laid off in 2013 are rehired in 2014 or 2015, before new employees are hired. This is why so few occupations require new employees in 2014. The number needed in 2015 is still muted due to expected rehiring of employees who lost their jobs in 2013.

Green boxes in Table 18 represent the high point year of new workers needed. For most occupations, this occurs in 2016 when the increase in annual capacity installed is 2 GW above the prior year and the previous peak annual installation in 2012. The next 2 years show increases in annual capacity installed of 1 GW versus the prior year. After that, the number of new workers needed each year declines as only attrition replacement is needed; there are no increases to annual capacity installed (it levels out at 16 GW per year). Since productivity increases are built into the model as well, not all employees lost due to attrition require replacement. For those occupations primarily in the O&M sector, peak hiring occurs in 2019. The decline in the number of new employees needed is minimal for these occupations, as they are correlated with cumulative installed capacity (which continues to increase). The increase in cumulative installed capacity is steady after 2019, and productivity increases cause the slight decline in the number of new hires needed.

[7] According to a study by Navigant Consulting, half the jobs in the wind industry and hundreds of U.S. factories could be lost by the first quarter of 2013 if the Production Tax Credit was allowed to expire on December 31 (AWEA Press Release; December 21, 2012).

Table 18. Estimates of Additional Employees Needed by Occupation Per Year

Annual GW Wind Capacity Installed	12	5	10	12	14	15	16	16	16	16	16	16	16	16	16	16	15	14	13
Cumulative GW Installed Capacity End of Year	59	64	74	86	100	115	131	147	163	179	195	211	227	243	259	275	290	304	317
New Workers Needed 2013-2030																			
	# of Current Workers (2012)	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**
Admin/clerical	**3,160**			437	618	434	439	256	253	249	245	242	238	235	231	227	81	71	62
Assembly workers	**1,230**			81	226	139	138	55	53	51	50	48	47	46	44	43			
Attorneys	**531**			87	106	78	79	50	49	49	48	48	47	47	46	45	22	20	18
Construction laborers	**4,056**			512	885	594	608	305	302	299	296	293	291	288	285	282			
Construction managers	**1,050**			101	211	136	137	62	61	60	58	57	56	55	54	53			
Development finance	**1,081**			71	199	122	121	48	47	45	44	43	41	40	39	38			
Development managers	**597**			57	120	77	78	35	35	34	33	33	32	31	31	30			
Development technical specialists	**393**			26	72	44	44	17	17	16	16	15	15	15	14	14			
Engineers	**5,992**			1,058	1,363	990	1,023	627	629	632	634	636	638	640	642	644	253	227	201
Government regulatory workers	**138**			9	25	16	16	6	6	6	6	5	5	5	5	5			
Land-leasing agents	**212**			14	39	24	24	9	9	9	9	8	8	8	8	7			
Managers of sales, operations & training	**1,975**		200	438	474	414	433	361	364	367	370	372	374	376	378	380	305	293	281
Manufacturing managers	**711**			68	143	92	93	42	41	40	40	39	38	37	36	36			
Manufacturing salespeople	**939**			62	173	106	105	42	40	39	38	37	36	35	34	33			
O&M accountants & bookkeepers	**448**	88	80	107	122	133	140	144	144	144	144	143	143	142	142	141	137	132	126
Paralegals	**72**			5	13	8	8	3	3	3	3	3	3	3	3	2			
Product designers	**1,264**			83	233	143	142	56	54	53	51	50	48	47	45	44			
Professional trainers	**432**			28	79	49	49	19	19	18	18	17	16	16	16	15			
Professors & teachers	**888**			58	163	100	100	39	38	37	36	35	34	33	32	31			
Research engineers	**929**			61	171	105	104	41	40	39	38	37	35	34	33	32			
Resource assessors & surveyors	**652**			51	125	78	78	33	32	31	30	30	29	28	27	27			
Scientists	**1,340**			88	247	151	151	60	58	56	54	53	51	50	48	47			
Supply chain & purchasing managers	**421**			28	77	47	47	19	18	18	17	17	16	16	15	15			
Trade workers	**5,561**			533	1,117	718	725	328	322	315	309	303	297	291	285	279			
Transportation/logistics workers	**844**			72	165	104	105	45	44	43	42	41	40	39	39	38			
Wind technicians	**11,475**	1,404	2,312	2,672	3,021	3,194	3,361	3,364	3,363	3,360	3,354	3,345	3,334	3,320	3,304	3,286	3,147	3,009	2,871
Other occupations not covered here	**19,341**		525	4,016	4,248	3,375	3,480	2,530	2,519	2,507	2,495	2,481	2,466	2,450	2,433	2,415	1,528	1,423	1,320

Estimate Number of Graduates Needed by Degree Type

Table 19 combines our projections for the number of new hires needed with the percentage of these new hires that would fulfill employers' interests in hiring people with wind-specific degrees or certification. The last table row shows the totals by certificate or degree type. This table outlines how many new hires are needed with these wind-specific degree levels.

Table 19. New Wind Energy-Specific Credential Programs Needed in the United States to Train the Future Wind Workforce

			Maximum New Hires Needed with Wind-Specific Degrees/Certificates				
Occupation	Maximum New Employees Needed in a Year	Year This Occurs	Post-Secondary Professional Certificate (Journeyman, Trade/ Technical Programs)	Associate's Degree	Bachelor's Degree	Post-Bachelor Professional Certification (e.g., CPA, PE, LEED)	Master's Degree, Ph.D., or Law
Admin/clerical	618	2016	23	22	29	1	3
Assembly workers	226	2016	60	50	-	-	-
Attorneys	106	2016	-	-	0	2	5
Construction laborers	885	2016	-	-	-	-	-
Construction managers	211	2016	16	4	29	6	4
Development finance	199	2016	-	1	6	3	3
Development managers	120	2016	2	-	14	10	10
Development technical specialists	72	2016	3	-	19	4	13
Engineers	1,363	2016	11	-	264	75	143
Government regulatory workers	25	2016	-	-	-	-	-
Land-leasing agents	39	2016	2	1	7	-	-
Managers of sales, operations, & training	474	2016	6	6	50	19	41
Manufacturing managers	143	2016	5	2	12	1	-
Manufacturing salespeople	173	2016	1	2	18	1	1
O&M accountants & bookkeepers	144	2019	-	1	7	1	1
Paralegals	13	2016	-	1	1	-	-
Product designers	233	2016	3	-	23	4	8
Professional trainers	79	2016	10	2	6	2	5
Professors and teachers	163	2016	6	11	8	6	49
Research engineers	171	2016	-	-	15	10	61
Resource assessors & surveyors	125	2016	4	7	11	-	11

			Maximum New Hires Needed with Wind-Specific Degrees/Certificates				
Occupation	Maximum New Employees Needed in a Year	Year This Occurs	Post-Secondary Professional Certificate (Journeyman, Trade/ Technical Programs)	Associate's Degree	Bachelor's Degree	Post-Bachelor Professional Certification (e.g., CPA, PE, LEED)	Master's Degree, Ph.D., or Law
Scientists	247	2016	-	-	9	5	35
Supply chain & purchasing managers	77	2016	1	1	4	0	-
Trade workers	1,117	2016	282	28	21	-	-
Transportation/logistics workers	165	2016	-	9	14	2	-
Wind technicians	3,364	2019	1,526	560	-	-	-
Other occupations	4,248	2016	789	286	228	61	159
		TOTAL	**2,749**	**996**	**795**	**212**	**553**

When attempting to estimate the number of wind-specific degree programs needed to satisfy industry demand, we must consider that many graduates choose to enter other industries upon graduation. Table 20 details graduates per year by wind-specific degree level, as well as the percentage of these graduates who move on to work in wind energy (keeping in mind that programs self-reported). While most graduates with wind-specific degrees from community and technical colleges do proceed to work in wind energy, the same cannot be said for university graduates. We believe a primary reason for this is that the university-level degree programs tend to be less focused on wind energy careers. The course work at the university level is broader (e.g., "Renewable Energy Policy" with a unit on wind power) and allows graduates to pursue more career paths.

Table 20. Percentage of Graduates Entering Wind Industry and Number of Graduates Per Program Per Year

		Percentage of Graduates Entering Wind Industry		Graduates Per Program Per Year	
Degree/Certificate	Institution Type	Median	Mean	Median	Mean
Post-secondary professional certificate (journeyman, trade/technical programs)	Community & tech colleges	90%	75%	10	17
Associate's degree					
Bachelor's degree	University	10%	15%	12	34
Post-bachelor professional certification (e.g., CPA, PE, LEED)					
Master's degree, Ph.D., or Law					

Table 21 shows the progression from the number of desired new hires with a wind energy-specific degree/certification to the number of graduates needed, given that not all graduates enter the wind industry. According to our data set, this may be an obstacle for university programs but not for community college programs in the future. The final step involves dividing the number of graduates needed by the estimated graduating class size to determine the number of educational programs needed, assuming that the class sizes remain similar to 2012 class sizes.

Appendix A explains how we estimated the number of wind-focused programs currently available to potential students. With the exception of associate's degree programs, it appears a shortfall exists in currently available training programs relative to projections of industry demand.

Table 21. Calculating Number of Wind Energy-Specific Programs Needed to Fulfill Projected Industry Demand (rounded to the nearest 10 with the exception of graduates per year)

Degree/ Certificate	Maximum New Hires Needed with Wind-Specific Degrees/ Certificates	Type of Institution Offering	Estimated Percent of Graduates Entering Wind Industry[8]	Number Needed to Graduate in Max Year	Estimated Graduates Per Program Per Year[9]	# of Programs Needed in United States*	# of Programs Currently Available	Difference
Post-secondary professional certificate (journeyman, trade/technical programs)	2,750	Community & tech colleges	83%	3,310	14	240	70	170
Associate's degree	1000	Community & tech colleges		1,200		90	90	0
Bachelor's degree	800	University	13%	6,120	23	270	20	250
Post-bachelor's professional certification (e.g., CPA, PE, LEED)	210	University		1,630		70	NA	NA
Master's degree, Ph.D., or Law	550	University		4,250		190	20	170

* Please see Appendices B and C for scenarios that explain how new employees could be trained without such a significant increase in number of programs.

A few important caveats must be considered for Table 21. The table shows the percentage of graduates who entered the wind industry in the recent past based on a relatively small survey of educational institutions. Although a small percentage of university graduates with wind-specific degrees entered the wind industry in the past year or two, this does not necessarily mean that the same percentage will follow suit in the future. If the wind industry needs these graduates, they could competitively pursue them.

Further, one must consider that the average class size provided by each school does not necessarily represent the maximum number of people who could graduate from each program.

[8] These estimates are the average of the mean and median figures presented in Table 20.
[9] Ibid.

While the potential expansion of class size was not included in our original school survey, we followed up with a small collection of university programs to determine whether enrollment in these degree programs was at maximum capacity or if additional students could be added without significant increases in expenditures. The four universities we discussed this issue with provided 14 wind-specific degree programs. Of these 14 programs, half claimed that educating additional students would require additional resources. The other half claimed that enrollment could increase without adding significant additional capital or human resources. Of the seven degree programs with available expansion, the schools reported that on average the number of graduates could double before significant additional resources would be required (see Appendix B for details).

Thus, if we combine these two factors and adjust our estimates accordingly, we would see that the number of additional educational programs required declines drastically relative to what is shown in Table 21. While these assumptions clearly reduce the magnitude of the shortfall, a shortfall is still apparent between the number of currently available programs and the number that will be needed to educate the workforce required to meet wind capacity growth outlined in the 20% Wind by 2030 report. Appendix C details this alternate scenario.

Conclusions

Employer Preferences for Wind Energy Training and Education

In most cases, employers rate experience in a relevant occupational field as more important in the hiring decision than experience in the wind energy industry. Hiring qualified candidates is generally considered "somewhat difficult," as opposed to "very difficult." The most difficult-to-fill positions are professors and teachers, followed by product design engineers.

Employers require a wide range of educational levels for their new hires. The most commonly required level of education is a bachelor's degree, although several occupations require an advanced degree. Exceptions to this include trade workers, assembly workers, and wind technicians (generally requiring some form of post-high school professional certification) and construction laborers (requiring a high school degree or equivalent).

Employers prefer candidates exposed to some form of wind energy training, but requirements for wind-specific professional certification or wind-specific college degrees are not the norm among the majority of employers. Wind industry employers only rank energy-specific professional certification as somewhat or very important for four occupations: professional trainers, research engineers, professors and teachers, and technical specialists. All employers believing it is important for wind technicians and assembly workers to hold a college degree feel that this degree should be wind energy-specific. Across all occupational classifications, fewer than 50% of employers cite a wind energy-specific college degree as "somewhat important" or "very important."

Availability and Graduation Rates of Wind Workforce Training and Educational Programs

A wide variety of program levels are offered, from 1-year post-secondary certificates to Ph.D. programs. Many of these programs are newer, and current graduation rates may underestimate

their future potential. Our sample did not include training courses that are offered outside of educational institutions, such as employer-sponsored short courses that provide field experience.

Associate's degrees and 1-year post-secondary certificates are more likely to definitively prepare graduates for work in the wind energy industry, as a high percentage of graduates move on to work in wind. University degree programs, including bachelor's degrees and higher, are much less likely to see their graduates enter the wind energy workforce. For university-level programs, this percentage may appear surprisingly low given that we are focusing on wind energy-specific degree programs. But as stated, most of the university degree programs had a broader curriculum than the community and technical colleges, which thus enabled graduates to pursue opportunities in a variety of industries.

Women in the Wind Industry

According to our survey, which only captures a segment of the domestic wind industry, women comprise approximately 20% of the known wind workforce. The variance across occupations is large. Six occupations of the 26 in our survey exhibited a majority of women in their workforce. These six included paralegals, admin/clerical, government regulatory workers, operations and maintenance accountants/bookkeepers, supply chain/purchasing managers, and development finance. The occupations with the lowest female representation were assembly workers, construction laborers, transportation/logistics workers, and wind technicians, each with less than 10%. One note of caution in this section is that according to BW Research staff, companies asked about numbers of female employees tend to over-report the number of women working in their company (Jordan 2012).

Growth of the Wind Workforce

Extrapolating the responses to our survey indicates that the wind workforce segment we have captured contains approximately 70,000 employees as of 2012. This is an educated assessment of the employers included in our research, not the entire U.S. wind industry. Of the workers we counted, most are employed in the utility-scale wind sector (~66,000), as opposed to smaller-scale commercial wind projects (~3,000). Following the capacity growth described in the 20% Wind by 2030 scenario, our methods project that the United States will require a wind industry workforce of approximately 105,000 by 2027 (including direct jobs and some supply chain jobs, but no induced jobs). In 2016, when the United States is projected to install 16 GW per year, the largest number of new hire workers is expected. Additional hires are needed each year to replace attrition, as well as for the continued growth of occupations that fall within the O&M sector. The number of O&M workers continues to grow as this figure is correlated with cumulative installed capacity, as opposed to annual capacity installed. In the long run, the number of new employees required each year declines over time as our modeling included anticipated increases in worker productivity.

Growth in Educational Programs Focusing on Wind Energy

For this report, we assumed that the sample data we collected on class size and the transition from school to industry are representative of all such educational programs (even though our sample was small). To meet the peak demands for an educated and well-trained wind workforce, the U.S. wind industry would need hundreds of degree programs focusing on wind energy. Based on our estimates, the United States would need approximately 250 to 300 post-secondary

professional certification programs, 80 to 120 associate's degree programs, 200 to 250 bachelor's degree programs, 40 to 80 post-bachelor's professional certification programs, and 125 to 175 master's level or higher programs. Given the 20% Wind by 2030 scenario, this peak demand for new hires generally occurs in 2016 for university graduates and 2019 for community college graduates. This number of programs is a sizable increase from what is currently available, with the exception of associate's degree programs.

Alternative methods to produce enough graduates include increasing the number of students per year per program (e.g., increase class size), or in the case of university graduates, developing industry-university collaborations that help steer a greater number of qualified graduates into the wind industry, such as internships. However, a shortfall would still exist, unless new programs are created.

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Appendix A: Estimate of U.S. Wind-Specific Degree Programs

Table 22 shows our best estimate of the number of wind-specific programs currently available in the United States. We derived this estimate by combining AWEA's educational program database[10] with Wind Power America's educational database,[11] resulting in 202 programs.

We then compared Windustry's school program list[12] with our list. Of the 37 programs listed by Windustry, 35 were also found on our aggregate list (a 95% match). However, it is logical to assume that the less-publicized programs would not be included in either of our lists, so we chose to lower this coverage factor from 95% to 90%. We then divided the number of programs in our list (202) by this 90% coverage factor, which increases our overall count estimate to 224.

Table 22. Estimate of Number of Current Degree Programs in the United States

Program Count	
69	Post-secondary certificate
89	Associate's degree
19	Undergraduate certificate
20	Bachelor's degree
8	Graduate certificate
14	Master's degree
6	Ph.D.
224	**Total**

[10] www.awea.org/learnabout/education/AWEA_Academic_Members.cfm
[11] www.windpoweringamerica.gov /schools /education/education_training.asp
[12] www.windustry.org/ resources/where-can-i-find-school-or-training-program-specific-renewable-energy

Appendix B: Limited Feedback on Potential Class Size Increases

While the potential expansion of class size was not included in our original school survey, we followed up with some university programs to determine whether enrollment in these degree programs was maxed out or whether additional students could be added without significant increases in expenditures. The four universities we conversed with on this issue possessed 14 wind-specific degree programs.

Table 23. Potential Class Size Increases

Programs for Which We Received Feedback on Expandability	Programs that Can Be Expanded without Additional Resources	Percentage of Programs that Can Be Expanded
14	7	50%

Total # of Graduates per Year in Classes that Could Be Expanded	Potential Number of Additional Graduates	% Increase in # of Graduates	% Programs Expandable X % Increase in # of Graduates
107	120	112%	**56%**

Appendix C: Alternate Scenario Produces Outcome with Smaller Shortfall of Programs

Following Table 21 in the report, we noted two factors that if considered would significantly reduce the number of additional wind energy educational programs that would need to be created to meet growing industry demand. In Table 24, we show the impact of employing these two factors in an alternate projection.

First, we increased the percentage of university graduates that chose to enter the wind industry upon graduation. Several factors could generate such an outcome, such as greater strategic recruiting by the industry, higher salaries, expanding internship programs, program scholarships and more. If we split the difference between the 13% estimate of those entering the wind industry among university graduates with the 83% estimate for community and technical colleges, we arrive at a 43% placement rate.

If we use the limited data we obtained for the possibility of expanding graduates per program, without schools needing to invest significant additional resources (i.e., just fill up empty seats in class), we would get a 50% increase in graduates per program per year (from 14 to 21 for community/ technical colleges and from 23 to 34 for university programs).

Table 24 shows the results of using these two alternative inputs. We can see that the number of programs required declines drastically relative to what is shown in Table 21. While these assumptions clearly reduce the magnitude of the shortfall, a shortfall is still apparent between the number of currently available programs and the number that will be needed to educate the workforce required to meet wind capacity growth outlined in the 20% Wind by 2030 report.

Table 24. Calculating Number of Wind Energy-Specific Programs Needed to Fulfill Projected Industry Demand (Alternate Scenario)

Degree/ Certificate	Maximum New Hires Needed with Wind-Specific Degrees/ Certificates	Type of Institution Offering	Estimated Percent of Graduates Entering Wind Industry	Number Needed to Graduate in Max Year	Estimated Graduates Per Program Per Year	# of Programs Needed in US	# of Programs Currently Available	Difference
Post-secondary professional certificate (journeyman, trade/technical programs)	2,750	Community & tech colleges	83%	3,310	21	160	70	90
Associate's degree	1,000	Community & tech colleges		1,200		60	90	-30
Bachelor's degree	800	University	48%	1,660	34	50	20	30
Post-bachelor's professional certification (e.g., CPA, PE, LEED)	210	University		440		10	NA	NA
Master's degree, Ph.D., or Law	550	University		1,150		30	20	10

Appendix D: BW Research Method for Estimating Today's Wind Power Employees

Note: BW Research provided this explanation.

Based on the sampling of wind companies conducted in August and September 2012, BW Research Partnership estimates that the 15 selected domestic wind industry segments[13] employ 69,126 workers.[14] To derive this estimate, BW Research first split the responses into two categories – those that reported working with large systems (i.e., utility-scale and large commercial wind turbines) and those that were pre-identified by the National Renewable Energy Laboratory (NREL) as working with smaller (typically residential) systems.[15] Mean wind employment was derived for each category (large = 27.32 workers; small = 13.71 workers).

In addition to mean employment, BW Research calculated the number of firms in each category. For large firms, the initial database (derived from AWEA membership lists, OpenEI, Windustry, NREL, and other sources) included 3,023 firms. NREL pre-identified 48 firms for the small firm database. A description of each process is detailed below.

Large-Wind Process

To calculate the number of large-wind firms, BW Research calculated several factors to refine the database. The first of these, churn, uses a ratio of calls reaching dead air, disconnections, fast-busy, wrong number, or no business locations, to the total number of telephone attempts made. This rate of 5.65% is then applied to the total firm database of 3,023.

Next, a "not-in-United States" rate is applied, similar to the above, for all firms that were asked the question (in this case, 38 of the 502 firms that reached the screener indicated that they were not located in the United States, a rate of 7.57%). This ratio is then applied to the post-churn database.

Ninety-one of the 463 respondents (19.65%) reported that their firms do not conduct wind-related activities, which again is applied to the database.

Finally, 30 of the 392 firms that were asked reported that they were small firms (thereby terminating) for a rate of 7.65%.[16]

Once each of these rates is applied, the 3,023 firms are reduced to 2,045 firms that are active, domestic, large-wind firms.

[13] It is important to note that several industry segments were not included for study, such as government. Other firms that are far removed from final goods and services, such as mining, smelting, etc., are also excluded due to said firms' inability to accurately allocate workers supporting the wind energy portions of their business.
[14] For the purposes of this memorandum, a "worker" is an employee that spends a majority of his or her time supporting the wind portion of the business. This is used as a reasonable proxy for full-time equivalent workers (FTEs) but is not interchangeable.
[15] Any firms that reported being "small" and were not pre-identified by NREL were terminated.
[16] Other factors, such as refusals, are excluded from the churn analysis.

Based on our research in other sectors, including national solar studies, we estimate that the original database accounts for approximately 85% of all firms. If this same rate is assumed in the current instance, the number of firms that meet the screener definition of a "wind firm" is 2,406. When this figure is multiplied by the (question 2) mean wind energy employment of 27.32, the result is 65,729 workers.[17]

Small-Wind Process

With a much smaller sample size, BW Research conducted a churn rate that included all relevant screen-outs. In the sample of 48 firms, 42 were attempted by telephone, and six were screen-outs, for a total churn rate of 14.29%. This reduces the overall universe to 41 firms.

In addition to these 41 firms, BW Research added approximately 169 small-wind firms that were deleted from the large universe sample for reporting that they worked with small systems. This results in 211 total small firms.[18] Using the same 85% capture rate assumption, this yields a total of 248 small wind firms.

With a mean wind employment of 13.71 workers[19] in the small universe, it is estimated that the small-wind universe employs 3,397 wind workers. These 3,397 workers, when added to the 65,729 workers in the large firm universe, equals 69,126 wind workers in the 15 selected wind industry categories.

[17] A further assumption is made that the 15% of firms not in the database have a similar profile (mean) to the 85% of firms included in the database.
[18] Due to decimal rounding.
[19] This assumes that the firms that screened out of the large sample have a similar profile (mean) to the pre-identified firms in the small universe sample.

Appendix E: BW Research Survey

Note: NREL did not edit this survey.

NREL Wind Employer Survey – Web Version

This research is being conducted on behalf of the **National Renewable Energy Laboratory, or NREL, and the Department of Energy** who would value your participation in a brief survey about the nation's wind industry workforce. This is the first attempt to understand the full breadth of the wind workforce in a systematic fashion. Your help in this project is the best way that we can arrive at a meaningful understanding of the workforce needs of this industry. Your individual responses will **not** be published; only aggregated information will be used in reporting the survey results.

The survey should take approximately 15 minutes of your time. By answering this survey, you can help inform how investments of time and money should be made to support the industry and how to prepare the present and future wind energy labor pool based on your needs. The survey is being hosted by BW Research for NREL.

[Show NREL Logo on Intro Page]

Screener Questions

A. What is the zip code of your current location?

_____ (Accept all five-digit responses)
Have check box for Refused

B. Is your company involved with an activity related to the wind energy industry? We define this as being directly involved with researching, developing, producing, manufacturing, distributing or implementing components, goods or services related to wind energy.
   1 Yes [CONTINUE]
   2 No [TERMINATE]
   3 Not sure [TERMINATE]

C. In which of the following wind industry segments does your organization participate?

Check all that apply.
1. Site Identification, Assessment or Pre-Development
2. Project Development: Legal, Real Estate or Finance
3. Project Permitting: Regulatory, Environmental or Wildlife Assessment
4. Manufacturing of Engineered Structures (tower, bedplate, hub)
5. Manufacturing of Drive Trains (couplings, bearings, gearboxes)
6. Manufacturing of Blades
7. Manufacturing of Power Equipment and Electronics (generators, cables, cooling, lighting, etc.)
8. Manufacturing of Sub-components or Materials

9. Nacelle Assembly
10. Sales, Distribution or Transport of Wind Energy Products (including OEM sales)
11. On-site Civil Works (roads, foundations, site improvements)
12. On-site Mechanical Assembly (installation of towers or turbines)
13. On-site Electrical Work (substation, collection grid, final grid connection)
14. Operations and Maintenance
15. Education, Training or Research

[ASK SCREENER D IF MORE THAN ONE SELECTED AT SCREENER C]

D. Which do you consider your organization's **primary** focus as it relates to the wind industry? [PIPE IN RESPONSES SELECTED AT SCREENER C, ACCEPT ONE]

1. Site Identification, Assessment or Pre-Development
2. Project Development: Legal, Real Estate or Finance
3. Project Permitting: Regulatory, Environmental or Wildlife Assessment
4. Manufacturing of Engineered Structures (tower, bedplate, hub)
5. Manufacturing of Drive Trains (couplings, bearings, gearboxes)
6. Manufacturing of Blades
7. Manufacturing of Power Equipment and Electronics (generators, cables, cooling, lighting, etc.)
8. Manufacturing of Sub-components or Materials
9. Nacelle Assembly.
10. Sales, Distribution or Transport of Wind Energy Products (including OEM sales)
11. On-site Civil Works (roads, foundations, site improvements)
12. On-site Mechanical Assembly (installation of towers or turbines)
13. On-site Electrical Work (substation, collection grid, final grid connection)
14. Operations and Maintenance
15. Education, Training or Research

E. What size systems does your firm typically work with? (do NOT ask for response 15 Question D)

Please choose one.

1 Residential or Small commercial
2 Large commercial or Utility-scale
3 Don't know/ Refused

F. How many business locations does your firm have in the U.S. that conduct wind activities?

IF Screener F > 1 or Refused, ask Screener G

G. Do you feel comfortable answering questions about the hiring and staffing needs of all of your firm's locations or just your current location?

1 All locations [CONTINUE]
2 Only my location [CONTINUE[– Please provide us with the email address of someone at your firm who is able to answer questions about hiring and staffing at other locations so that we can send him or her a survey.
Collect Email: _____

3 No - Please provide us with the email address of someone at your firm who is able to answer questions about hiring and staffing at your firm so that we can send him or her a survey.
Collect Email: _____

IF Screener G = 1 , state: "For the purposes of this survey, the term "firm" shall refer to all of your U.S. business locations.
If Screener G = 2 or Screener F=1, state "For the purposes of this survey, the term "firm" shall refer to your current business location only"
If Screener G = 3, terminate

SECTION 1 - Firm Profile

1. Including all full-time and part-time employees, how many permanent employees work at your firm?

Record # of employees _____

Have check box for Refused

IF q1=0 Skip q2 and ask q3. Then Skip q4 thru q10

2. If you currently have [TAKE Q1 #] full-time and part-time permanent employees at your firm, how many of these workers, spend at least 50% of their work time, supporting the wind energy portion of your business?

Record # of employees _____

Have check box for Refused

[Q2 SHOULD BE LESS THAN OR EQUAL TO Q1 - BUILD IN CHECK]

3. How many temporary workers do you have at your firm that spend at least 50% of their work time supporting the wind energy portion of your business?

Record # of employees _____

Have check box for Refused

[IF MORE WIND ENERGY WORKERS THAN LAST YEAR (Q3>Q4) Ask Section 2, Otherwise Skip to Section 3]

SECTION 2 – Workforce Development and Training Needs
Occupation-Related Questions

[NOTE - PLEASE COMMUNICATE TO RESPONDENT THAT WE WILL BE USING GENERAL OCCUPATIONAL TITLES RATHER THAN SPECIFIC JOB TITLES THAT MAY BE USED WITHIN EACH ORGANIZATION]

4. 8.4. The next section of the survey will ask about the occupations within your organization. The occupational titles we are using may differ from the specific position titles used in your organization. For these questions, please try to equate your organization's specific position titles with the more general ones we will use here.

   Please only assign one occupation to each employee. If they fall into more than one category, please assign them to the occupation in which they devote more of their time.

   Does your firm employ individuals in positions matching the following general occupational titles?

   (1 = Yes, 2 = No, 3 =DK/NA)

** After Screener D create a new variable titled sdprime. If only one choice selected at Screener C, sdprime= Screener C choice, If multiple choices at Screener D, sdprime=Screener D choice **

sdprime	Occupation Title	Occ # in the data
14	Accountant or bookkeeper	1
2	Accountant, loan specialist or finance officer	2
1	Admin/ Clerical	3
2		
3		
4		
5		
6		
7		
8		
9		
10		
11		
12		
13		
14		
15		
3	Archaeologist	4
2	Attorney	5
10		
14		
3	Biologist	6
3	Civil Engineer	7
11	Construction laborers	8
12		
13		
1	Construction manager/Land Acquisition	9
3	Electrical Engineer	10
1	Engineer	11
2		
10		
12		

13 14 11		
4 5 6 7 8 9	Engineers and product designers	12
4 5 6 7 8 9	First line managers (including ES&H)	13
3	Government Regulatory Workers	14
11 12 13	Heavy equipment operators (including cranes)	15
2	Land Leasing Agent	16
10	Logistics technician	17
14 15	Management	18
10	Manager	19
2	Paralegal	20
15	Professional trainer	21
15	Professor, teacher or educator	22
2	Project Management	23
11 12 13	Project managers	24
15	Research engineer	25
1	Resource Assessment Analyst	26
4 5 6 7 8 9 10	Salesperson	27
1	Scientist/biologist	28
4 5 6 7 8 9	Supply chain managers/purchasing	29
11	Surveyors	30
2	Technical Specialist	31

12 14	Technician	32
7 9	Technicians and Assembly Workers	33
4 5 6 7 8 9 11 12	Trade workers and specialists	34
13	Trade workers and specialists, including electricians	
10	Transportation workers	35

5. Thinking about the wind energy portion of your business, how many individuals do you have at your firm that are currently employed either full-time, part-time or temporarily in each occupation?

A	Occupation 1	#### (Record Number)
B	Occupation 2	#### (Record Number)
C	Occupation 3	#### (Record Number)
D	Occupation 4	#### (Record Number)

CONTINUE FOR AS MANY OCCUPATIONS IN EACH CATEGORY

[CREATE INTERNAL CONTROL SO THAT THE COMBINED OCCUPATIONAL EMPLOYMENT IS NOT MORE THAN OVERALL WIND FOCUSED EMPLOYMENT Q2 +Q3]

6. Please indicate the level of difficulty your firm has in finding qualified applicants who meet the organization's hiring standards.

	No difficulty	Some difficulty	Great difficulty	Don't know/ Refused
A. Occupation 1	1	2	3	4
Occupation 2	1	2	3	4
Occupation 3	1	2	3	4
Occupation 4	1	2	3	4

7. For each of the following occupations, please select the preferred educational attainment for new hires.
   1 High school diploma or less
   2 Post secondary professional certificate (journeyman, trade/technical programs)
   3 Associate Degree
   4 Bachelor Degree
   5 Post Bachelor professional certification (examples: CPA, PE, LEED)
   6 Master Degree, PhD or Law

8. Thinking about the different types of [pipe in occupation] that work in the **wind energy portions of your business**, do any of these individuals require the following skills sets or educational certifications, and if so are they somewhat important or very important?

RANDOMIZE

	No, this Is Not Needed	Somewhat Important	Very Important	Don't know/ Refused
A. Prior work experience in a related field				
B. Prior work experience specifically in Wind Energy 1		2	3	4
C. Wind Energy specific training (including courses, workshops, conferences, etc)				
D. Professional Certification in their occupation				
E. Wind Energy specific Professional Certification 1		2	3	4
.....1		2	3	4
F. College Degree				
G. Wind Energy specific college degree.....1		2	3	4

9. For each of the following occupations, please provide any specific training credentials that you deem valuable.

   [open end]

10. For each of the following occupations, how many of the [pipe in q5] are women?

    Record # of women _____

SECTION 3 – Revenue Question

11. Approximately how much of your firm's work, in terms of total revenue, is related to wind energy products or services?

    1 All of it (100%)
    2 Half to most of it (50% to 99%)
    3 A quarter but less than half of it (25% to 49%)
    4 Less than a quarter (1% to 24%)
    5 Don't know/ Refused

SECTION 4 – Installation Questions

NREL truly appreciates your assistance in answering all the previous questions related to assessing your wind energy workforce. The purpose of the next question is to help us correlate how many employees are needed for different levels of Wind Energy production. Please provide your best estimate.

Ask Q12 of those responding 1,2,3,10,11,12,13,14 from Screener Question D

12. How many megawatts (MW) or kilowatts (kW) of Wind Energy, or Wind Energy systems, has your firm developed, evaluated, sold, or installed of over the last 12 months?

    Record _____

    Have check box for Refused

Ask Q13 of those responding 15 from Screener Question D

13. How many people were educated or trained in Wind Energy by your firm or institution over the last 12 months?

    i. Record _____

    ii. Have check box for Don't know/Refused [IF THAT IS CHECKED BRING UP INTERVAL ESTIMATE]

    a. 1 to 49
    b. 50 to 249
    c. 250 to 499
    d. 500 to 999
    e. 1,000 or more

14. If your firm were selected to provide goods or services for a newly planned, 100 MW wind farm, how many total employees would contribute labor hours to the project?

    Record _____

Ask Q15 of those responding 4,5,6,7,8,9 from Screener Question D

15. Thinking of an average (for example, 2.0 MW) wind turbine, how many labor hours of work at your firm is attributed to producing the components necessary for one wind turbine?

    Record _____

SECTION 5 – Permission Questions

16. Are you interested in receiving future information about the findings of this research?

1 Yes
2 No

17. Would you be willing to be contacted by educators and researchers to participate in a follow-up interview regarding this research?

1 Yes
2 No

18. Would you like to have your name included into our raffle drawing for a chance to win an iPad 3?
    1. Yes
    2. No

Thank you for completing the survey. Since it sometimes becomes necessary for the project manager to confirm responses to certain questions, please verify your contact information.

This information will also be used to ensure that we do not call you as part of our telephone survey effort for this project.

A. First and Last Name_____
B. Position_____
C. Phone_____
D. Email _____
E. Company Name_____
F. Company Address _____
G. Company City _____
H. Company State _____
I. Company Zip _____

Thank you very much for your time.

J. Survey Date_____
K. Survey Time_____