NATIONAL ENERGY TECHNOLOGY LABORATORY

2021 NETL WORKFORCE READINESS PLAN

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U.S. DEPARTMENT OF ENERGY | NATIONAL ENERGY TECHNOLOGY LABORATORY

DISCLAIMER

Background

Advances in technology occur at a rapid pace; consequently, skills and training must evolve to successfully deploy emerging and cutting-edge technologies. Using a questionnaire designed to elucidate skills necessary in technologies ready for commercial deployment in 3–5 years, the workforce readiness plan was conceived to help define emerging skills or occupations associated with these emerging technologies. This initiative intends to inform training providers and industry representatives of emerging skill sets. Ideally, the data collected here shall inform both about future curriculum or upskilling requirements that may be necessary in the energy and manufacturing industries. This paper highlights lessons learned and information gleaned from the pilot "workforce readiness plan" effort.

The concept of a workforce readiness plan, or summary of collected project data, originated from discussions occurring at various Appalachian Regional Commission (ARC) listening session workshops held with community colleges in 2017–2018. A prevalent topic in these workshops and follow-on discussions with NETL Regional Workforce Initiative (RWFI) stakeholders focused on this issue of training and educational providers understanding what occupations were in demand in the regional energy and manufacturing sectors, as well as what type of current and future skills and education were required for those in-demand jobs. In light of advances in technologies associated with these occupations, stakeholders wanted to know if there is a way to gain insight into the upskills necessary with recent technological advances that may give a competitive advantage to workers and job seekers. NETL funds research and development (R&D) in technological advances in energy and advanced manufacturing, with a number of these funded projects being far along in the scale of technological readiness. The technologies can exist anywhere from the readily commercialized to those multiple years from commercialization. The initial workforce readiness plan concentrated on these late-technology-readiness-level projects. The original workforce readiness plan/questionnaire consisted of four queries.

1) **Availability and accessibility of training programs:** *Describe the necessary skillset and training required to prepare the workforce needed to commercialize/deploy the technology. Discuss availability of training and educational programs to fill current or projected activity/commercialization need.*
2) **Ongoing or planned collaborations with education and training providers:** *Describe plans and approaches to access the necessary training for the workforce needed to commercialize/deploy the technology. This includes coordination with educational institutions such as community colleges, technical schools, and universities, company-led in-house training, union training, etc. Please identify any institutions with which working relationships exist.*
3) **Identify any necessary certificates, certifications or other educational attainment involved in this technology/activity.** *Examples include apprenticeships, certificates, certifications, academic training or other programs available through in-house training or in coordination with education institutions such as community colleges, technical schools, universities, unions or other professional associations.*
4) **Identify any Economically Distressed Communities or state or federal designated Opportunity Zones or other geographically defined empowerment zones where this activity may occur.** *Example: Appalachian region distressed or defined counties*

Initial Results

The initial effort consisted of 16 projects responding to the workforce readiness questions. Of the 16 responses, there were 58 unique occupations identified. Of these, 13 of 16 plans identified skills necessary for those occupations. The question receiving the least response was the request to identify whether the project was occurring in an economically distressed community or otherwise federally designated opportunity zone. This may have occurred because the type of geographical designations that these programs use is not easily understood. Additionally, these designations apply to workforce funding opportunities or programs and may

not be appropriate for this type of R&D competitive funding opportunities, which are typically not held to any specific geography or economic condition. Fourteen projects addressed the availability of training and education required for the occupation and a statement of current needs or demands with varying detail. Most replies indicated a steady and sufficient supply of the occupations within their project scopes, and most of the occupations were related to the Oil and Natural Gas (ONG) sector, which is in line with a number of NETL late-stage R&D projects. Though it might be assumed that these R&D projects and prospective industry sectors have a strong acclivity towards professional degrees, of the 58 unique occupations identified, 25 were technical workforce occupations that require a degree or certificate that can be completed in less than two years.

Tracking Responses: Workforce Workplan Database

Job/Career Field Name	Skills Needed	Education Requirements	Availability of Training Programs	Any Other Relevant Items Provided?
Big Data Programmer/Analyst	• Efficiently extract large scale complex business data (time series data, structured/unstructured) from various data sources and prepare them for data analytics. • Partner with product experts, leverage common open-source machine learning/deep learning packages for identifying data patterns/trends or building predictive models. • Deploy solutions to business units using software technologies to generate measurable values for businesses. • Grasp the application of the latest machine learning and artificial intelligence open-source packages, cloud, and distributed computing technologies to ensure the best technologies are implemented to meet businesses' data challenges.	• Undergraduate degree in Data Science, Computer Science, Math, or Statistics. • For candidates who hold an engineering degree, we require candidates have taken data science classes already. • 7 years of experiences with a minimum of 2 years experiences in extracting the data, using common classification or regression open-source packages through R or Python.	Yes	
Geologists	• Geologists with a passion for subsurface materials and skillsets such as geologic characterization, well log and core analysis, petrophysical calculations, geostatistics, model development, and field work are needed to quantify rock property estimations and integrate subsurface interpretations using different datasets.	• Undergraduate & Professional	Yes	

Figure 1. Workforce Workplan Database Example

To better track current and future responses, the NETL RWFI created a workforce readiness plan database (Fig 1) that tracked four main topics: job/career identified, skills needed, educational requirements, and availability of training. In total, across all responses there were 122 job/career entries, 79 skills needed entries, 98 educational requirements entries, and 104 availabilities of training provided. In the "availability of training provided" response, many provided generic examples of training and did not directly answer if there was sufficient training available. For some of the responses, there was significant information provided for the skills needed. Quality information like this may be beneficial for end users as it provides a very thorough and complete description of skills necessary for an occupation. An example of useful skills information that can be found in the database is found below describing skills desired in a welder (Fig 2) as well as what type of materials or welding processes are necessary for the activity that the funding performer is involved.

Welder	
Skills Needed	• Be able to perform welding on various materials at required position using different welding processes, including, but not limited to, GTAW, SMAW, FCAW, GMAW and SAW. • Construction experience is required on wellhead platform, topsides, structure, piping, pressure vessels and practical knowledge of applicable codes and standards such as AWS, ISO, API, ASTM and ASME. Experience on construction yard is required. • Comprehensive knowledge in welding, material, and NDE. • Lay out, position, fit, and weld various piping and structural components, including pipes, flanges, fittings, valves, piping supports, structural plates, beams, etc., in accordance with the supplied piping/structural fabrication drawings. • Set up, troubleshoot, and operate welding machines according to job specifications and welding procedures. • Adjust valves, gauges, and flames as needed and be capable of handling compressed gas and oxygen cylinders safely. • Operate air arc gouger, grinder, and other industry machines, tools, and equipment.

Figure 2. Example of substantive entry of skills necessary in welding

Occupations Identified		
Top 20 Occupations		
Geologists/Geophysicist	Fluids Engineer	Production Engineers
Electrician/Electronics technician	FPGA Programmer	Production Manager
Petroleum Engineer	Array Manufacturing Subcontractors	Project Life Cycle Management Engineer
Computer Aided Design/Engineer	GIS Mapping Specialist	Project Manager
Electrical Engineer	Health and Safety Operators	QA (Quality Assessment)
Pipeline Installer	HMI/SCADA Automation Engineer	Refinery Gaugers
Welder	Hydraulic Fracturing Engineers	Refinery Operators
Chemical Engineer	Instrument Technicians	Researcher/Entrepreneur
Mechanical Engineer	Instrumentation Engineer	Drillers
Reservoir Engineer	Legal Counsel	Rig Operator
Software engineers	Machine Learning Expert	Roustabouts
Big Data Anaylst	Man-Machine Interface Designer/Programmer	Safety Officer
Big Data Programmer	Data Scientists	Sensor Engineer
Civil Engineer	Network Designer	Drillers
Construction Engineer	Opto-Mechanical Systems Engineer	Survey Crew
Construction Safety Officer	Packaging Engineer	Technician (General)
Controls Engineer	Electritician/Electronics Technician	Board layout and Manufacturing Subcontractors
Controls Technician	Petroleum Pump System Operators	Welhead Operator
Driver-CDL	Physicist	Fiber Optic technician
Field Engineers	Environmental Safety Operators	Field Operators
Emerging Occupations of Note		
Big Data Anaylst	GIS Mapping Specialist	Researcher/Entrepreneur
Big Data Programmer	HMI/SCADA Automation Engineer	Sensor Engineer
Computer Aided Design/Engineer	Machine Learning Expert	Software Engineers
Data Scientists	Man-Machine Interface Designer/Programmer	
FPGA Programmer	Network Designer	

Figure 3. Unique Occupations Identified, Top 20 Occupations and Emerging Occupations of Note

Occupations Identified

Of the 122 entries for Job/Career Field name, 58 recognizable unique occupations were identified. Most of these occupations are to be expected in late-stage ONG activities (Fig 3). The occupations list contains a mixture of occupations that require an undergraduate (UG) four-year degree, a postgraduate (PG) degree, a high school (HS) degree, a certificate (CERT) program, a two-year associates degree (AA) or some other type of technical training (union training, apprenticeships, etc.).

Top 20 Occupations Identified	Educational Requirements
Geologists/Geophysicist	UG/PG
Electrician/Electronics technician	AA/HS/Cert.
Petroleum Engineer	UG/PG
Computer Aided Design/Engineer	UG/PG
Electrical Engineer	UG/PG
Pipeline Installer	AA/HS/Cert.
Welder	AA/HS/Cert.
Chemical Engineer	UG/PG
Mechanical Engineer	UG/PG
Reservoir Engineer	UG/PG
Software engineers	UG/PG
Big Data Anaylst	UG/PG
Big Data Programmer	UG/PG
Civil Engineer	UG/PG
Construction Engineer	UG/PG
Construction Safety Officer	AA/HS/Cert.
Controls Engineer	UG/PG
Controls Technician	AA/HS/Cert.
Driver-CDL	AA/HS/Cert.
Field Engineers	UG/PG

Figure 4. Educational requirements in the top 20 Occupations listed.

While most of the top 20 occupations involve some sort of undergraduate or higher degree, there are a significant number (six) of occupations that do not (Fig 4). As an example of the spread between two-year and four+ year entries, geologists/geophysicists were mentioned nine times while electricians/electronics technicians were reported six times. Four out of the ten top occupations are considered part of the technical workforce. These jobs, whether part of the professional (Fig. 5) or technical workforce (Fig. 6) are well compensated occupations expected to exhibit growth in the next 10 years.

Quick Facts: Chemical Engineers	
2020 Median Pay	$108,540 per year $52.18 per hour
Typical Entry-Level Education	Bachelor's degree
Work Experience in a Related Occupation	None
On-the-job Training	None
Number of Jobs, 2020	26,300
Job Outlook, 2020–30	9% (As fast as average)
Employment Change, 2020-30	2,400
Quick Facts: Mechanical Engineers	
2020 Median Pay	$90,160 per year $43.35 per hour
Typical Entry-Level Education	Bachelor's degree
Work Experience in a Related Occupation	None
On-the-job Training	None
Number of Jobs, 2020	299,200
Job Outlook, 2020–30	7% (As fast as average)
Employment Change, 2020–30	20,900

Figure 5. Pay, educational, work experience, current and future employment, and job growth expectations for occupations identified that require at least an undergraduate degree (modified tables from the Bureau of Labor Statistic' Occupational Outlook Handbook)

Quick Facts: Welders, Cutters, Solderers, and Brazers	
2020 Median Pay	$44,190 per year $21.25 per hour
Typical Entry-Level Education	High school diploma or equivalent
Work Experience in a Related Occupation	None
On-the-job Training	Moderate-term on-the-job training
Number of Jobs, 2020	418,200
Job Outlook, 2020–30	8% (As fast as average)
Employment Change, 2020–30	34,100
Quick Facts: Electricians	
2020 Median Pay	$56,900 per year $27.36 per hour
Typical Entry-Level Education	High school diploma or equivalent
Work Experience in a Related Occupation	None
On-the-job Training	Apprenticeship
Number of Jobs, 2020	729,600
Job Outlook, 2020–30	9% (As fast as average)
Employment Change, 2020–30	66,100

Figure 6. Pay, educational, work experience, current and future employment, and job growth expectations for occupations identified that require less than an undergraduate degree (modified tables from the Bureau of Labor Statistic' Occupational Outlook Handbook)

An interesting observation about the occupations identified is the appearance of occupations with an anticipated high degree of portability across diverse technical fields. In the top 20, these include computer-aided design/engineers (4), software engineers (3), big data analysts (2), and programmers (2). Indeed, when we look at the total occupations reported holistically (Fig 3), we note that the occupations tilt heavily towards high tech skills in IT and computer programming, and awareness of basic and complex programming language and data utilization.

Conclusion

While there is now a better general appreciation of the fact that a high-skilled workforce supports R&D and high-tech industries, it is worth noting that our results further support this trend.

Jobs and occupations that are part of this highly skilled technical workforce are well paid and exhibit an increased demand in the general U.S. employment ecosystem. Whether it is in the professional or technical workforce, the general trend is towards a more skilled workforce. Of the 20 most identified occupations, six required an associate degree or less, and of the 58 total identified occupations, nearly half were part of the technical workforce.

Perhaps one of the most interesting observations from this pilot exercise was the identification of emerging high-skilled/high-tech occupations that are potentially valuable across a wide array of technical fields. We may be able to begin to see the emergence of skills and occupations across energy sectors with this type of analysis. These types of early observations will be beneficial for academia and the workforce training ecosystem in preparing for changes in curriculum and training to match these emerging occupations. While this workforce workplan was focused on the late-stage technologies that NETL funds, if the workplan was conducted at other national laboratories, with their own technology foci, you may see the same trend appear, where emerging skills and occupations may be elucidated.

The workforce workplan may also be an effective tool for a more complete discussion of the skills necessary for energy occupations. Some entries provided very significant discussions on the skills involved in an occupation, and this is of particular interest to education and training providers. In much the same way that the workplan may be able to identify emerging occupations, it should also be able to identify skills associated with those emerging occupations or within the traditional occupations. As an example, the occupation of welding is always evolving to meet the new technological breakthroughs in advanced materials. An exercise like this may be able to see what the emerging need would be with respect to new materials. This was the topic of a recent joint workforce funding opportunity by NETL and the Appalachian Regional Commission, the ***Advanced Welding Workforce Initiative***. The opportunity was conceived and deployed as a response to the growing demand for welders trained in advanced technical skills critical to power plants, automotive, aerospace, and aviation industries. The funding totaled $1M and will help support five schools/training providers in implementing specialized curricula and learning modules in welding, robotics, process control, and advanced manufacturing techniques. The workforce workplan may in the future be useful in early identification of these upskilling opportunities in different energy and advanced manufacturing technology and industry sectors.

It is important to note that this pilot exercise is not a survey. The workforce workplan is intended to be used as a passive monitor of the knowledge and expertise from funding performers on what their technologies potential footprint is with emerging technologies or with technologies that are at a deployment stage. It is also not a measure of jobs or employment. There is not a correlation between types of occupations identified and a direct job involved in the funded program. The workplan does demonstrate what R&D investments indirectly

contribute to present and potential future jobs. It does provide an interpretation of supply and demand in the very focused confines of the type of technologies and industries where the funding is involved.

The initial workplan inquiry provided useful information tied to the original intent of the activity, namely, it gave a snapshot of the indirect occupations and skills necessary for late-stage technologies that NETL manages. The first iteration of the workforce workplan provided valuable insight on how a second version or expanded version of a workplan 2.0 may look like. It would be helpful to include a template or example of a good response, as the substantive description of occupations and skills varied from each applicant. Thus, providing an example of a good response will help standardize the results as well as provide a baseline for information provided. Quality responses could also be helped by including more instructions as well as definitions for some of the content asked for. For example, the economic impact question in version 1.0 did not receive many usable entries, and this is probably a direct result of not including enough definitions of the terminology used to define geographic preference and economic development categories. This may also be an opportunity to add or subtract questions and a review of relevant and useful questions is forthcoming.

This initial pilot effort has shown that conceptually, the workforce workplan may provide useful information for policy makers, employers, and educational providers. If applied to other laboratories or if the research portfolio queried were to increase, the workforce workplan may provide the best picture yet of the occupations and skills impacted directly and indirectly by federal R&D funding as well as emerging occupations and skills involved in the technologies that NETL, DOE, and the other national laboratories fund.