Truckee Meadows Community College
Division of Technical Sciences: Energy Technologies Program
Reno, NV 89512

DOE-TMCC-01/2014 April 2014

Geothermal Technologies Office
Final Technical Report

Nevada Renewable Energy Training Project: Geothermal Power Plant Operators

by
Norma Velasquez-Bryant, Co-Principal Investigator
James E. Nichols, Principal Investigator

Grant# DE- EE0003776

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ABSTRACT

The purpose of this project was to develop and institute a training program for certified geothermal power plant operators (GPO). An advisory board consisting of subject matter experts from the geothermal energy industry and academia identified the critical skill sets required for this profession. A 34-credit Certificate of Achievement (COA), Geothermal Power Plant Operator, was developed using eight existing courses and developing five new courses. Approval from the Nevada System of Higher Education Board of Regents was obtained. A 2,400 sq. ft. geothermal/fluid mechanics laboratory and a 3,000 sq. ft. outdoor demonstration laboratory were constructed for hands-on training. Students also participated in field trips to geothermal power plants in the region. The majority of students were able to complete the program in 2-3 semesters, depending on their level of math proficiency. Additionally the COA allowed students to continue to an Associate of Applied Science (AAS), Energy Technologies with an emphasis in Geothermal Energy (26 additional credits), if they desired. The COA and AAS are stackable degrees, which provide students with an ongoing career pathway. Articulation agreements with other NSHE institutions provide students with additional opportunities to pursue a Bachelor of Applied Science in Management or Instrumentation. Job placement for COA graduates has been excellent.

INTRODUCTION

Truckee Meadows Community College (TMCC), Reno, Nevada, is home to over 12,000 students (FactBook, 2013). Established in 1971, TMCC is located in Washoe County, population 422,994, and comprises four academic divisions: School of Sciences, School of Liberal Arts, School of Business and Entrepreneurship, and Workforce Development and Continuing Education. The student profile at TMCC consists of 35% ethnic minorities, 56% females, and a median age of 23 years. Ninety-four percent of the students are Nevada residents, and the number of Washoe County School District graduates who attend TMCC in the fall or spring term immediately following graduation from high school is 33%. Data show that 95% of TMCC graduates stay in Nevada.

In September 2009, TMCC was awarded a $500,000 grant by the Department of Energy, Geothermal Technologies Office, to plan, develop, and institutionalize a training program for certified geothermal power plant operators. At that time, TMCC had a 2-year Associate of Applied Science (AAS) in Renewable Energy that included courses in solar, wind, geothermal, and energy efficiency. The purpose of this project was to develop and institute a training program for certified geothermal power plant operators (GPO). An advisory board consisting of subject matter experts from the geothermal energy industry and academia identified the critical skill sets required for this profession. A 34-credit Certificate of Achievement (COA), Geothermal Power Plant Operator, was developed using eight existing courses and developing five new courses. With the approval of the advisory board, the curriculum for the COA program of study was submitted for institutional approval. Final approval for the COA was obtained from the Nevada System of Higher Education (NSHE) Board of Regents. The Board of Regents has a strict approval procedure for new curricula that requires the curriculum to be academically rigorous, and that a need exists in the state and region for a workforce with the proposed credentials. The process from design to implementation was approximately 18 months, with the first five students officially enrolled in the COA program in the fall 2011 semester. Student enrollment has been steadily increasing with a graduation rate of 96% (n=27).

METHODS, ASSUMPTIONS, AND PROCEDURES

Objectives

The tasks presented here are in accordance with the *"Best Practices and Recommended Guidelines for Renewable Energy Training"* published by the Interstate Renewable Energy Council (IREC), September, 2008.

Task 1.0 Identify curriculum needs to include real world preparation for an occupation. Subject matter experts and representatives from the geothermal energy industry identified the critical skill sets needed for a highly-qualified power plant operator. These required skills and knowledge desired were used to develop a program of study for a Certificate of Achievement, Geothermal Power Plant Operator, shown in Table 1.

Task 1.1 Identify the subject matter experts to aid in defining the courses and the syllabi. The subject matter experts identified for this project were leaders in geothermal energy technology. Fortunately, northern Nevada has an abundance of geothermal resources and there was an active geothermal community for recruitment of these experts, which also included retired members. Currently, there are approximately a dozen geothermal companies headquartered in the Reno area.

Task 1.2 Identify certifications and licensure requirements. All geothermal power plants typically provide on-the-job training with a high degree of rigor to attain specified levels of proficiency for each plant. The COA developed through this project is being used by employers as a strong foundation for additional training. Feedback from industry has indicated that the COA graduates are ready for more advanced hands-on training upon graduation. At this time, there are no standardized licensures required, and the COA may be used as a standard readiness assessment.

Task 1.3 Compile a list of tools and equipment for which students should have proficiency. The students were required to use information systems and programs typically found in power plant operation. These programs included word processing, spreadsheets, and databases. The use of these computer skills were embedded in the online hybrid format of all classes, including report writing, data collection and analyses. Students were also introduced to the different types of plants, as well as the parts and equipment associated with each.

Task 2.0 Conduct a labor market assessment to match training with local labor needs. TMCC worked closely with representatives from the geothermal energy industry through an established advisory board to ensure that the needs of the industry were met. Courses were developed with close guidance from the advisory board and were assessed by the project team and employers to verify that the courses were applicable and met industry standards-of-practice. Appropriate modifications were made as the content and industry standards changed.

Task 2.1 Define the target population. The GPO training program was targeted toward individuals who were interested in employment in the renewable energy field. Many of these students were displaced and/or underemployed workers that had difficulty recovering from the

recent economic recession. These individuals came from various backgrounds that included construction, and hospitality and warehouse workers, to name a few. The students also included single mothers and other typically underrepresented populations in the field. In fall 2012, a scholarship program was developed through grant funding from the Department of Labor's Workforce Investment Act (WIA) to train low-income students in the GPO program, totaling $422,000 over two years. Funding approval is pending for the next academic year—$236,000. The scholarships included the cost of tuition, fees, and books. In addition, funds from the first year award were used to purchase a mobile laptop cart with 12 laptops for student use. Thus far, the GPO scholarship program has funded 27 students, with a 96% completion rate, and 96% job placement. Overall, there are typically 25 students enrolled in the program (both scholarship and non-scholarship) each semester, and that number is steadily increasing.

Task 2.2 Determine current and potential employers of these individuals and the projected number of full-time and part-time positions. The project team has compiled a database of geothermal energy companies in the United States. Workforce needs are not readily available as the geothermal energy industry has been experiencing a cyclic phase of peaks and valleys, depending on the cost of other energy resources. However, most companies have indicated that there will be a need to fill positions due to attrition and retirement, particularly with an aging workforce retiring over the next five years. Team members have been contacted by international interests as well, regarding the availability for training outside the U.S. This will be the next step in disseminating the training program to the workforce in other countries.

Task 3.0 Develop courses with an emphasis on high quality course design. Course design was focused on optimal, state-of-the-art teaching techniques with a complete set of classroom learning aids. During the development of the five new courses, the team worked with the subject matter experts in collaboration with an Instructional System Designer. This included the identification of delivery systems and appropriate learning tools. The courses were taught in a variety of delivery systems including the traditional classroom, hybrid (both online and in the classroom), and strictly online.

Task 4.0 Ensure that prerequisites are established for each course and that students are evaluated based on examinations or other assessments. The GPO curriculum was designed to offer courses in a sequence that flowed seamlessly to promote student success. Each course syllabus clearly identifies the course objectives and outcomes to be achieved. Homework assignments, quizzes, and examinations were used to measure student learning. Prerequisites were established through input from the advisory board and

subject matter experts. Table 1 shows the program of study developed by the advisory board and the GPO project team. Course descriptions are shown in Appendix A.

Table 1. Geothermal Plant Operator, Certificate of Achievement (34 credits)

Semester	Prerequisites	Course	No	Title	Credits
1	ENG 090, 098 or Accuplacer	ENG	101	Composition I	3
	MATH 096 or Accuplacer	MATH	126	Pre-Calculus I	3
	None	AIT	110	General Industrial Safety	1
	None	ENRG	110	Basics of Electricity	3
	None	CE	201	Workplace Readiness	3
				TOTAL CREDITS:	**13**
Semester	**Prerequisites**	**Course**	**No**	**Title**	**Credits**
2	ENRG 110	ELM	127	Introduction to AC Controls	3
	ENRG 110	ELM	129	Electric Motors and Drives	3
	ENRG 110	ELM	233	Introduction to Instrumentation	3
	ENG 101 MATH 120	ENRG	171	Well Design, Construction, and Geology	1
	ENG 101 MATH 120	ENRG	173	Geothermal Plants, Turbines, and Generators	3
				TOTAL CREDITS:	**13**
Semester	**Prerequisites**	**Course**	**No**	**Title**	**Credits**
3	ENG 101 MATH 120	ENRG	172	Fluids, Piping, Valves, and Pumps	4
	ENG 101 MATH 120	ENRG	174	Environmental Regulations for Geothermal Plant Operators	1
	ENG 101 MATH 120 ENRG 173	ELM	134	Fundamentals of Process Controls	3
				TOTAL CREDITS:	**8**

Additional assessment data was collected for both formative and summative program evaluation to determine success. A longitudinal assessment has been implemented to determine both student and employer satisfaction with the training program. An annual survey was conducted in December 2013 for the first group of graduates (N=5) , and all indicated they were (a) still working in the geothermal industry, (b) extremely satisfied with their job, and (c) the program provided the critical tools necessary to do the job. Results from the employer survey are pending. An example of student comments:

"*I'm very thankful and satisfied to be in my new career right now. I work for a great company and I enjoy my work schedule. I'm consistently learning everything I can from Enel. I'm very happy to have been in the Truckee Meadows Community College Geothermal Scholarship Program."*

"I loved the geothermal program! I have applied to many plants and have received prompt and encouraging replies. ….I feel very prepared for my new career. Thanks to the program!"

Task 5.0 Provide field and laboratory experiences. A significant component of the training program was the inclusion of field and laboratory experiences. A 2,400 sq. ft. geothermal/fluid mechanics laboratory and a 3,000 sq. ft. outdoor demonstration laboratory were constructed for hands-on training. Students also participated in field trips to geothermal power plants in the region each semester. The fluid mechanics laboratory has been equipped with the latest state-of-the-art equipment, and includes a Hydraulic Bench with a Bernoulli's Apparatus, a Pump Lab, Rankine Cycle, and Fluid Friction Measurement System. A Multi-Purpose Flume (5m) will be delivered in the fall 2014 semester. All of the equipment was purchased through various additional grant awards prepared by the principal investigators on this project, totaling $145,000. TMCC also has an extensive instrumentation laboratory and machine shops for classroom experiments that provided students the opportunity to analyze real data. The ability to use data, to understand how data are collected, and how data collection methods can affect the validity of the data are critical for a geothermal power plant operator.

Task 6.0 Develop alliances and establish an active advisory board. An advisory board was established consisting of geothermal energy representatives, researchers from the University of Nevada, Reno, and staff from TMCC. The purpose of the advisory board was to (1) provide program support, (2) be a source of adjunct faculty, (3) be a source of subject matter experts, (4) be a source of donations for equipment and supplies, (5) provide information about changing technologies and required skill sets, and (6) act as external assessors of the program, reviewing the progress of the program and offering guidance for program improvement. The

board has continued to actively participate in the ongoing activities of the program as it continues to grow. A list of board members is shown in Appendix B.

Task 7.0 Establish partners for articulation agreements with technical high schools, other community colleges, and four-year degree granting institutions. It is important for graduates to understand the need for continuing education. Changes in technology, differences in local operations and plant configurations require the ability to adapt quickly and efficiently. The majority of the GPO students were able to complete the program in 2-3 semesters, depending on their level of math proficiency upon entering the program. Students that did not have the prerequisite math skills were provided the opportunity to enroll in a five-week "fast-track" online math sequence, which remediated any weaknesses in this area. This has been a common roadblock to student success in other programs at TMCC as well, and results of the GPO fast-track math remediation process have shown remarkable outcomes. All of the students who participated in the extra remediation program have persisted and have either graduated, or are on track to graduate in the spring 2014 semester.

The GPO training program provides students who obtain the Certificate of Achievement (COA) an opportunity to continue studies for an *Associate of Applied Science (AAS), Energy Technologies with an emphasis in Geothermal Energy* degree (26 additional credits), if they desired. The COA and AAS are stackable degrees, which provide students with an important career pathway. TMCC has also established articulation agreements with other NSHE institutions, Great Basin College (Elko, Nevada) and Nevada State College (Henderson, Nevada) to provide students with additional opportunities to pursue a Bachelor of Applied Science (BAS) in Management or Instrumentation. Additionally, students who complete the BAS in Management through Great Basin College may enter a Master of Business Administration program at the University of Nevada, Reno. These degrees are delivered online, which allows students in remote areas where most power plants are typically located, to continue their educational goals while continuing to work.

The TMCC project team has also worked closely with the National Science Foundation's (NSF) California Regional Consortium for Engineering Advances in Technological Education, (CREATE) to identify opportunities for articulation throughout the West. Interest from institutions in southern California regarding the COA GPO training program has been positive, and the College of the Desert is working toward implementing a similar program.

Task 8.0 Project management and reporting. The project team consisted of a small staff that administered the program, and were assisted by TMCC faculty, student services, administrative, financial, and public information departments. All progress reports, both financial

and narrative, were submitted in a timely manner, and the program was administered on budget.

RESULTS AND DISCUSSION

The majority of students are able to complete the program in 2-3 semesters, depending on their level of math proficiency upon entering the program. Additionally the COA allows students to continue to the redesigned Associate of Applied Science (AAS), Energy Technologies with an emphasis in Geothermal Energy (60 credits), if they desire. The COA and AAS are stackable degrees, which provide students with an ongoing career pathway. Articulation agreements with other NSHE institutions provide students with additional opportunities to pursue a Bachelor of Applied Science in Management or Instrumentation. Job placement for COA graduates has been excellent, with various employers such as Gradient Resources, Enel Green Power, Cal Energy (Mid-American Renewals), and Calpine Geysers. As the number of graduates continues to increase, interest from employers has also grown.

CONCLUSION

The Geothermal Power Plant Operator training program has provided (a) students the opportunity to obtain high-paying positions in the renewable energy field, (b) industry the opportunity to hire highly-qualified individuals with a strong foundation in the basics of power generations, thus reducing the time and cost of training “people off the street,” and (c) a solution to the negative impact the recession has had on the state of Nevada, by getting people back to work. Many of the graduates were caught in a cycle of no jobs available, out of work too long, and exhausting all other financial aid available for day-to-day living. These graduates are leaving TMCC with a Certificate of Achievement and obtaining jobs with an average starting salary of $22.00 per hour, plus full benefits, which helps them with their own economic recovery. Plus, with the “stackable degrees” design, they can embark on a path of lifelong learning.

REFERENCES

“Best Practices and Recommended Guidelines for Renewable Energy Training,” the Interstate Renewable Energy Council (IREC), September, 2008.

California Regional Consortium for Engineering Advances in Technological Education, (CREATE), National Science Foundation (NSF). http://www.create-california.org/

Truckee Meadows Community College (TMCC), *FactBook*, 2013.

APPENDIX A

Truckee Meadows Community College
Geothermal Plant Operator Training Program
Certificate of Achievement (34-credits)
Course Descriptions: 2013-2014 College Catalog

ENG 101 Composition 1 3.00 credits
Prerequisite: Grade of C- or better in ENG 98R; Qualifying Accuplacer score for Reading Comprehension of 86+ and WritePlacer of 5+. Qualifying ESL Accuplacer scores: Reading Comprehension of 86+ and LOEP WritePlacer score of 6.
Writing intensive course designed to strengthen college level writing skills, with particular attention to persuasion, analysis, synthesis and an introduction to research methodologies. Focus on process through drafting, revising and editing is emphasized. Conventions of standard English are reviewed. Additionally, critical reading strategies of college level texts are developed.

MATH 126 Pre-Calculus 3.00 credits
Prerequisite: A grade of C or better in MATH 96 or 97 or equivalent or qualifying ACCUPLACER, ACT/SAT test results.
A graphing calculator may be required for this course. The study of equations and inequalities involving radical, rational, quadratic or absolute value terms. Also includes polynomial, rational, exponential and logarithmic functions, their graphs and applications.

AIT 110 General Industrial Safety 1.00 credits
Prerequisite: None
This is a general safety course for an industrial environment. Students will learn OSHA regulations, personal safety and understand the importance of safe work habits. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ENRG 110 Basics of Electricity 3.00 credits
Prerequisite: None
An introductory course in electrical principles, applications, and distribution. This course provides an overview of safety, circuits, wiring, grounding, resistance, current, voltage, and troubleshooting. Students will develop a basic understanding of how electricity is distributed and the implications of the emergence of renewable energy resources. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

CE 201 Workplace Readiness 3.00 credits
Prerequisite: None
Prepares students with critical skills to secure and maintain employment. Students will learn to communicate in multiple modes to address workplace needs, solve problems using critical thinking, understand work-related systems, maintain safe and healthful working conditions, practice ethical and legal behavior consistent with workplace standards, and enhance work outcomes through leadership, self-management, and teamwork. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ELM 127 Introduction to AC Controls 3.00 credits
Prerequisite: ENRG 110.
An introduction to hard-wired industrial control. Emphasis is on the control of electrical motors through relay logic. Topics include circuit design using industrial control diagrams, circuit construction with industrial control panels and devices, troubleshooting methodology and practice. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ELM 129 Electric Motors and Drives 3.00 credits
Prerequisite: ENRG 110 and ELM 127.
This is a hands-on course designed to give experience with basic motor construction and principles of operation of single and poly phase motors. Also covered are variable speed drives and braking. The course covers AC and DC motors with an emphasis on maintenance and troubleshooting. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ELM 134 Fundamentals of Process Controls 3.00 credits
Prerequisite: MATH 126; ENG 101 or 113 or higher; ENRG 173
This course will provide students with hands-on practical knowledge of geothermal process controls and instrumentation used in a geothermal power plant. Topics will cover the commonly used types of instruments (temperature, pressure, flow, level, speed, vibration), actuators and positioners (pneumatic, hydraulic), and controllers (PLCs, governors, voltage regulators, dedicated loop controllers), and materials of construction, selection, principles of operation, common references, performance evaluation, maintenance practices, and calibration. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ELM 233 Introduction to Instrumentation 3.00 credits
Prerequisite: ENRG 110.
An introduction to the fundamentals of instrumentation and process control-concepts and measurement of physical variables and brief descriptions of individual processes and Combination of processes used in industry. Theory of operation and application of associated process instruments are covered.

ENRG 171 Well Design, Construction, and Geology 1.00 credits
Prerequisite: Math 96 or higher; ENG 101 or 113 or higher.
This course is designed to give students a basic understanding of the energy source fueling a geothermal power plant. Students will also gain an understanding of the basic principles of geology as they relate to geothermal systems. Methods of drilling, well construction and development will also be covered. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ENRG 172 Fluids, Piping, Valves and Pumps 4.00 credits
Corequisite: MATH 126 or higher.
Prerequisite: ENG 101 or 113 or higher.
This course is designed to give students a basic understanding of fluid properties, dynamics, and systems equipment. Class topics will include gases, vapors, liquids, density, viscosity, laws of thermodynamics and conservation, and the relationship of pressure, elevation head, friction losses, parallel flow, series flow, work, and water hammer. Students will also gain an understanding of the common equipment found in fluid systems such as piping, valves, pumps, compressors, and turbines. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ENRG 173 Geothermal Plants, Turbines, and Generators 3.00 credits
Prerequisite: MATH 96 or higher; ENG 101 or 113 or higher.
This course is designed to give students a basic understanding of thermodynamics and geothermal power plant systems equipment. Class topics will include the laws of thermodynamics, heat engine power cycles, geothermal power plant configuration, and common equipment used in geothermal power plants. Students will also gain an understanding of the principles used in geothermal power plant operation, common references, performance evaluation, and maintenance practices. This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

ENRG 174 Environmental Regulations for Geothermal Plants 1.00 credits
Prerequisite: ENG 101 or 113 or higher
Students will be familiarized with the required permits and regulations governing the operational phase of a Geothermal Power Plant. Typical permits covered will include Federal Land Agency approvals and mitigation measures, State drilling permits and well closure requirements, State operating permits (UIC, NPDES, and Solid Waste Site permits), and conditional or special use permits issued by local entities (counties and municipalities). This course may not transfer to a baccalaureate degree of art or science within the universities in the Nevada System of Higher Education (NSHE).

APPENDIX B

TMCC Geothermal Advisory Board Members

Name	Contact Information	Organization
Jim Nichols, P.E. Principal Investigator	jnichols@tmcc.edu	TMCC Engineering
Dr. Wendy Calvin, Director Great Basin Center for Geothermal Energy	wcalvin@unr.edu	University of Nevada, Reno Geological Sciences
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Tom Buchanan	tbuchanan@ormat.com	Ormat
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Stephen Schumacher	bigshoenv@sbcglobal.net	Consultant
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