Solar Design/Install Labor Quantification

Cooperative Research and Development Final Report

CRADA Number: CRD-23-23744

NREL Technical Contact: Vignesh Ramasamy

NREL is a national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy
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Contract No. DE-AC36-08GO28308

Technical Report
NREL/TP-7A40-92239
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NOTICE

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Cooperative Research and Development Final Report

Report Date: 9/16/2024

In accordance with requirements set forth in the terms of the CRADA agreement, this document is the CRADA final report, including a list of subject inventions, to be forwarded to the DOE Office of Scientific and Technical Information as part of the commitment to the public to demonstrate results of federally funded research.

Parties to the Agreement: Logically Engineered Automation Features Ltd.

CRADA Number: CRD-23-23744

CRADA Title: Solar Design/Install Labor Quantification

Responsible Technical Contact at Alliance/National Renewable Energy Laboratory (NREL):

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Sponsoring DOE Program Office(s):

Office of Energy Efficiency and Renewable Energy (EERE), Solar Energy Technologies Office

Joint Work Statement Funding Table showing DOE commitment:

Estimated Costs	NREL Shared Resources a/k/a Government In-Kind	Participant In-Kind	TOTALS
Year 1	$75000.00	$10000.00	$85000.00
TOTALS	$75000.00	$10000.00	$85000.00

No participant funds-in

Executive Summary of CRADA Work:

The goals of this project were to quantify the rate and/or total expected labor expenditure of engineers designing solar arrays and electricians installing solar across a spectrum of project sizes and configurations. Specifically, procuring and analyzing labor data from solar engineering firms relating to the amount of time it takes an engineer to design a solar project, the amount of time it takes an engineer to perform a wiring or stringing design, the amount of time it takes an electrician to install a solar project and the amount of time it takes electricians to install the strings of a solar array. Then these details could be analyzed to evaluate labor intensity for solar design/installation. These goals were unable to be completed because the participant was unable to collect the necessary data for analysis.

CRADA benefit to DOE, Participant, and US Taxpayer:

- Helps SETO understand any significant labor savings that can be achieved in commercial solar design process using participant's solar design tool.
- Uses the laboratory's TEA competencies.

Summary of Research Results:

Task Descriptions: Participant will:

Task 1: Conduct Survey - Leaf along with NREL will conduct a survey with industry participants that will help collect data for a simplified bottom-up model to understand the impact of labor cost related to electrical design and installation of typical solar projects. Both involved parties are expected to work together and exchange necessary data/information to complete the cost impact analysis within 12 months from the project kick-off date.

Task 1 Description/Results/Explanation:

NREL and participant were involved in consistent weekly meeting for the first three months to use existing data to build a labor savings bottom-up cost model framework involving various activities involved in a solar design process. NREL developed a framework as shown in figures below to produce baseline results.

Project Specs	Value	Unit
Project Capacity	5	MWdc
ILR	1.2	#
Labor Burden Rate	54%	%
Module Specs	**Value**	**Unit**
Max Power	500	Wdc
Open-Circuit Voltage	45.3	Voc
Voltage at max power	36.8	Vmpp
Current at max power	8.40	Impp
Operating Temp Coefficient	-0.33%	%/C
Min. cell temperature of PV module	-10	'C
Max. cell temperature of PV module	70	'C
Temperature difference between STC and min. cell tem.	-35	'C
Temperature difference between STC and max. cell tem.	45	'C
Max. open-circuit voltage Ocmax	50.5	V
Min. open-circuit voltage: Ocmin	31.3	V
Inverter Specs	**Value**	**Unit**
Nominal Power AC (kW)	500	
Power Factor (cos ϕ)	1	
Efficiency (%)	97.50%	
Nominal Power Ratio (N)	0.90	
Active Power AC (kW)	500	
Input DC Power Inverter (kW)	513	
PV array power (kW)	570	
Max Input Voltage (V)	600	
Min Input Voltage (V)	330	
Max Input Current (A)	1250	
Inverter # Estimation		**Unit**
Number of modules #	10,000	
Max #modules per string	12	
Min #modules per string	11	
# of strings	909	
# of cominer boxes	76	
# of modules per inverter	149	
# of inverters	6	

Figure 1. Project and hardware specifications

$/Wdc	Engineering Design	Unit	Qty	Labor Hours/Unit	Avg. no. of labor hour	No. of. Laborers
$ 0.011	Civil Engineering				136.28	5
$ 0.023	Structural Design				284.94	5
$ 0.026	Electrical Design				322.11	5
$ 0.005	Panel Layout Analysis	#Modules			66.90	5
$ 0.012	String Length Estimation	#Strings			148.67	5
$ 0.019	DC Cabling Design	LF			235.39	5
$ 0.015	Stringing Design	#Strings			185.83	5
$ 0.005	Voltage Drop Calculation				61.94	5
$ 0.025	Single/Three Line Diagram				309.72	5
$ 0.005	Creating Tables/Schedules				61.94	5
$ 0.015	Permitting Process				185.83	5
$ 0.005	Hardware Selection				61.94	5
$ 0.166	**Engineering Design**					
$/Wdc	Installation Labor	Unit	Qty	Labor Hours/Unit	Avg. no. of labor hour	No. of. Laborers
$ 0.035	AC electrical				185.25	15
$ 0.072	DC electrical				379.32	15
$ 0.025	Module install				76.27	20
$ 0.026	Racking install				80.68	20
$ 0.018	Foundation install				60.65	20
$ 0.176	**Installation Labor**					

$/Wdc	Engineering Design	$/labor hour (unburdened)	$/labor hour (burdened)	Total labor $ (unburdened)	Total labor $ (burdened)
$ 0.011	Civil Engineering	$ 37.13		$ 25,300.00	$ 55,000.00
$ 0.023	Structural Design	$ 37.13		$ 52,900.00	$ 115,000.00
$ 0.026	Electrical Design	$ 37.13		$ 59,800.00	$ 130,000.00
$ 0.005	Panel Layout Analysis	$ 37.13		$ 12,420.00	$ 27,000.00
$ 0.012	String Length Estimation	$ 37.13		$ 27,600.00	$ 60,000.00
$ 0.019	DC Cabling Design	$ 37.13		$ 43,700.00	$ 95,000.00
$ 0.015	Stringing Design	$ 37.13		$ 34,500.00	$ 75,000.00
$ 0.005	Voltage Drop Calculation	$ 37.13		$ 11,500.00	$ 25,000.00
$ 0.025	Single/Three Line Diagram	$ 37.13		$ 57,500.00	$ 125,000.00
$ 0.005	Creating Tables/Schedules	$ 37.13		$ 11,500.00	$ 25,000.00
$ 0.015	Permitting Process	$ 37.13		$ 34,500.00	$ 75,000.00
$ 0.005	Hardware Selection	$ 37.13		$ 11,500.00	$ 25,000.00
$ 0.166	**Engineering Design**			**$ 382,720.00**	**$ 832,000.00**
$/Wdc	**Installation Labor**	**$/labor hour (unburdened)**	**$/labor hour (burdened)**	**Total labor $ (unburdened)**	**Total labor $ (burdened)**
$ 0.035	AC electrical	$ 28.96		$ 80,474.51	$ 174,944.58
$ 0.072	DC electrical	$ 28.96		$ 164,777.24	$ 358,211.38
$ 0.025	Module install	$ 37.13		$ 56,640.30	$ 123,131.09
$ 0.026	Racking install	$ 37.13		$ 59,912.80	$ 130,245.22
$ 0.018	Foundation install	$ 35.00		$ 42,457.94	$ 92,299.86
$ 0.176	**Installation Labor**			**$ 404,262.78**	**$ 878,832.13**

Figure 2. Labor hours and costs

Task 2: Additional Tasks - Other work at the direction of the Participant, consistent with the scope and subject to the availability of funding.

Task 2 Description/Results/Explanation:

Participant wanted to collect necessary data from the external industry stakeholders via a survey to inform the model before and after using participant's solar design tool. They also equipped few solar design and engineering firms with free licenses to test the labor efficacy of LEAF's solar design tool. The survey was designed with NREL's input and then passed on to external stakeholders. This task remains incomplete till date as the participant could not collect necessary data to inform the model.

Last the NREL heard from the participant was in January 2024 when the participant said they did not have enough data to populate the model and produce any desired results.

Task 3: The NREL will prepare a CRADA Final Report: Preparation and submission in accordance with the terms of this agreement.

Task 3 Description/Results/Explanation:

NREL could not prepare a complete report that can be published due to challenges faced by the participant in collecting the data required to populate the labor savings bottom-up cost model.

Subject Inventions Listing:

None

ROI #:

None