

TIME STUDY: FIRST SOLAR SERIES 4™ MODULES WITH QUIKCLAMP™

Installer: Data was utilized from time studies on two installations with leading regional EPCs as well as installation estimates developed internally and in consultation with experienced installers

Site Conditions: Flat to gently sloping. Relatively easy post driving with insignificant number of refusals

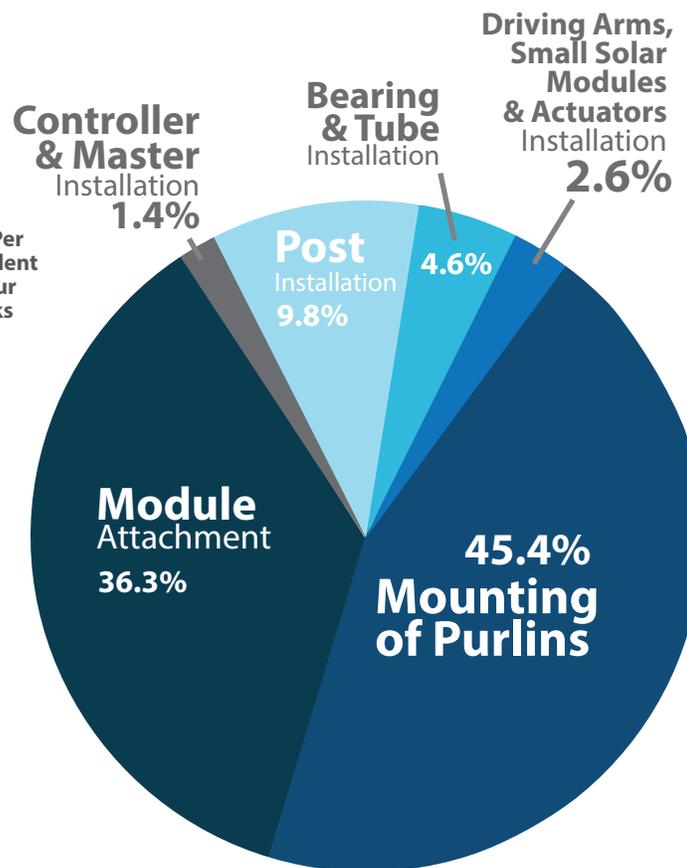
Modules: Study utilized 120 watt First Solar Series 4 ("FSLR4") modules

Time frame: Various sites from 2016 through 2018

Weather Conditions: Varying from dry to raining

For purposes of this study data for the most basic installation methodology was utilized, with no prepanelization for modules.

	Worker Hours Per Module Equivalent (%)	Worker Hours Per MW (120 W modules)	Worker Hours Per Module Equivalent (Based on 8 hour workday, breaks included)
Post Installation	9.8%	72	0.0086
Bearing & Tube Installation	4.6%	34	0.0041
Driving Arm, Small Solar Module & Actuator Install	2.6%	19	0.0023
Mounting of Purlins	45.4%	333	0.0400
Module Attachment	36.3%	267	0.0320
Controller & Master Installation	1.4%	10	0.0012



STUDY RESULTS

The study concludes that the installation rate per module equivalent for the installation period studied was:

.0882 worker hours per module equivalent including moving materials from staging area

1.089 MW system installation rate with 20 workers per week

ABOUT THE STUDY

Installation of posts, bearings & tubes, driving arms, small solar module & actuators, mounting of purlins and modules, controllers and master controllers. The following time study project was conducted to develop a valid assessment of the work content of the labor related to installation tasks in terms of hours spent on each task and total hours spent per module equivalent for installation of the completed system. The study was conducted by interviewing site supervisors regarding workplace production on hourly and daily basis with employees assigned to perform specific tasks. Hours noted were based on an 8 hour workday. The study analyzes each operation in terms of completed units, each unit being one installed module equivalent. Please note that installation rate may vary from site to site and installer to installer. It is advisable to receive training from GameChange personnel for first time installers of GameChange systems. This Time Study has been provided as an installation aid only and should not be relied upon for purposes of project job cost estimation since there are many variables involved with each project and other considerations.

STUDY DETAILS

The employee work hours were studied relating to six principal installation tasks.

Task 1: Installation of Posts

This task consists of staging posts at marked locations throughout the site, then driving them. In an average estimated time study, one team of two men with an operator in a skid steer staged posts at a rate of 963 over two full 8 hour days. In another time study in normal soils conditions, a team of two men with a pile driver drove 175 posts per day. A typical average number of posts for 180 FSLR4 modules is 11.

Worker hours per FSLR4 module equivalent per module including moving materials from staging area:

$$= (2 \text{ workers} \times 8 \text{ hours}) / (175 \text{ posts} \times (180 \text{ modules}/11 \text{ posts})) + (3 \text{ workers} \times 8 \text{ hours} \times 2 \text{ days}) / (963 \text{ posts} \times (180 \text{ modules}/11 \text{ posts})) = .0086 \text{ worker hours per module}$$

Task 2: Installation of Bearings and Tubes

In a typical relevant time study, workers started with mounting the center bearing, then put standard bearing bottoms on finger tight. Next, they used a jig made of a 6 inch outside diameter conduit cap with a barrel laser to align. Then they torqued the bottom of bearing, installed tubes, and squeeze splices. Lastly, they installed plastic halves, top of bearings and screwed in capture rings. Tubes and bearings were brought out by the crew as they were installed. Tubes, splices, and bearings for 963 posts were completed in one day with 8 workers including movement of material from staging area. A typical average number of piles for 180 FSLR4 modules is 11.

Worker hours per FSLR4 module for installation of bearings and tubes (including squeeze splices) including movement of materials from staging area:

$$= (8 \text{ workers} \times 8 \text{ hours}) / (963 \text{ posts} \times (180 \text{ modules}/11 \text{ posts})) = 0.0041 \text{ worker hours per module}$$

Task 3: Installation of Driving Arms, Small Solar Modules and Actuators

In a typical representative time study, one operator and two additional workers staged 132 sets of drive arms, actuators and small solar modules in 2 hours with one lull. 6 workers installed all components in this task on 132 tables in one day. A typical average number of FSLR4 modules is 180 per tracker.

Worker hours per FSLR4 module equivalent for installation of driving arms, small solar modules and actuators including movement of materials from staging area:

$$= (6 \text{ workers} \times 8 \text{ hours plus } 3 \text{ workers} \times 2 \text{ hours}) / (132 \text{ tables} \times 180 \text{ modules per table}) = 0.0023 \text{ worker hours per module}$$

Task 4: Mounting of Purlins

Purlins and hardware were placed onto tubes finger tight by two worker crews. Then, AutoSquare&Space™ jig was used by one worker to properly space and square purlins and they were then torqued to specification. 3 workers in 1 day mounted 600 purlins. Movement of purlins and hardware from staging area to field was completed with one operator on one skid steer. Two workers installed the purlins. Two purlins are required for every three FSLR4 modules in a typical 3 up landscape configuration.

Worker hours per FSLR4 module equivalent for mounting of purlins including movement of materials from staging area:

$$= (3 \text{ workers} \times 8 \text{ hours}) / 600 \text{ modules} = 0.0400 \text{ worker hours}$$

Task 5: Mounting of PV Modules

This task consists of mounting FSLR4 modules. Three modules are mounted on two purlins using (4) mid clips, (4) end clips, (8) button head bolts and (8) serrated flange nuts. A four worker and one operator team uses one skid steer to move modules from staging area, would mount them at an estimated 1,250 modules per day, and remove boxes from field and place into dumpster.

Worker hours per module equivalent for mounting of FSLR4 PV modules including movement of materials from staging area:

$$= (5 \text{ workers} \times 8 \text{ hours}) / 1,250 \text{ modules} = .0320 \text{ man hours per module}$$

Task 6: Installation of Controllers and Master Controllers

One worker installed 40 node controllers per day using an ATV to move materials from staging area. Each node averaged 42.95 modules. A two worker team installed the master controllers in two hours. Each master covers an average of 200 node controllers. A typical table with one node controller has 180 FSLR4 modules.

Worker hours per silicon module equivalent for installation of controllers and the master controller including movement of materials from staging area:

$$= (1 \text{ worker} \times 8 \text{ hours}) / (40 \text{ controllers} \times 180 \text{ modules per controller}) + (2 \text{ workers} \times 2 \text{ hours}) / (1 \text{ master controller} \times 200 \text{ node controllers} \times 180 \text{ modules}) = .0012 \text{ man hours per module}$$