Genius Tracker™

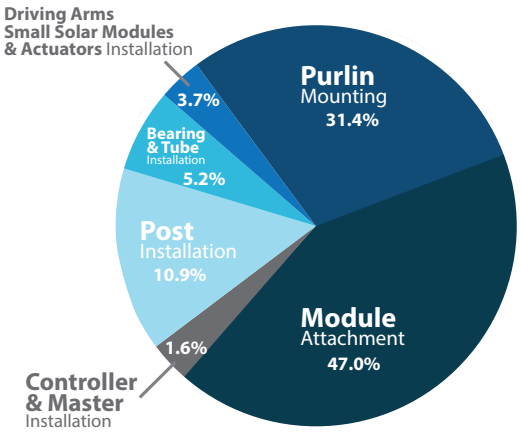
GAMECHANGE SOLAR
REPOWERING THE PLANET

TIME STUDY: FIRST SOLAR MODULE VS. SILICON MODULE WITH PURLINS

Modules: Study utilized silicon framed modules of 320 watts, First Solar Series 4™ ("FSLR4") modules of 120 watts
Site Conditions: Flat to gently sloping. Relatively easy post driving with insignificant number of refusals.
Weather Conditions: : Varying from dry to raining

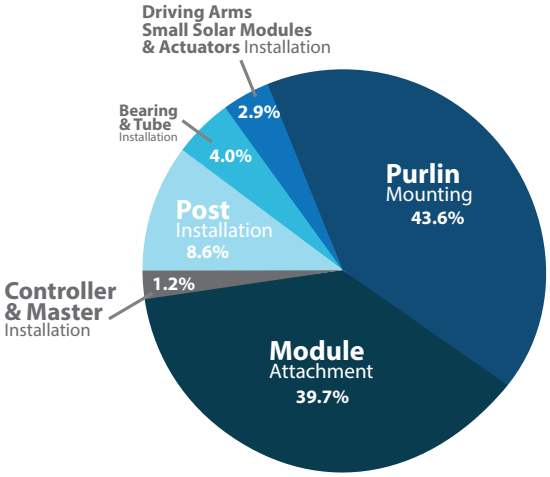
Silicon Module:

	Worker Hours Per Module Equivalent (%)	Worker Hours Per MW (320W modules)	Worker Hours Per Module Equivalent (Based on 8 hour workday, breaks included)
Post Installation	10.9%	58	0.0185
Bearing & Tube Installation	5.2%	27	0.0087
Driving Arm, Small Solar Module & Actuator Install	3.7%	20	0.0063
Purlin Mounting	31.2%	165	0.0528
Module Attachment	47.4%	250	0.0800
Controller & Master Installation	1.6%	8	0.0027



FSLR4 Module:

	Worker Hours Per Module Equivalent (%)	Worker Hours Per MW (120W modules)	Worker Hours Per Module Equivalent (Based on 8 hour workday, breaks included)
Post Installation	8.6%	72	0.0086
Bearing & Tube Installation	4.0%	34	0.0041
Driving Arm, Small Solar Module & Actuator Install	2.9%	25	0.0029
Purlin Mounting	43.6%	367	0.0440
Module Attachment	39.7%	333	0.0400
Controller & Master Installation	1.2%	10	0.0012



STUDY RESULTS

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

Silicon module

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

1.515 MW system installation rate with 20 workers per week

First Solar Series 4™ module

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

0.952 MW system installation rate with 20 workers per week

ABOUT THE STUDY

Data was utilized from time studies on two installations with leading regional EPCs as well as installation estimates from a large leading national EPC.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 primarily 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. 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.

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Task 1: Installation of Posts

This task consists of staging posts at market locations throughout the site, then driving them. In an average estaimted 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 84 silicon modules is 11, average number of posts for 180 FSLR4 modules is 11.

Worker hours per silicon module equivalent per module including moving materials from staging area:
= (2 workers x 8 hours) / (175 posts x (84 modules/11 posts)) + (3 workers x 8 hours x 2 days) / (963 posts x (84 modules/11 posts)) = .0185 worker hours per module

Worker hours per FSLR4 module equivalent per module including moving materials from staging area:
= (2 workers x 8 hours) / (175 posts x (180 modules/11 posts)) + (3 workers x 8 hours x 2 days) / (963 posts x (180 modules/11 posts)) = .0086 worker hours per module

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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" outside diameter conduit cap, then used a barrel laser to align, then torque bottom of bearing, then install tubes and squeeze splices and then plastic halves, top of bearing and screw 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 84 silicon modules is 11, average number of piles for 180 FSLR4 modules is 11.

Worker hours per silicon module equivalent for installation of bearings and tubes (including squeeze splices) including movement of materials from staging area:
= (8 workers x 8 hours) / (963 posts x (84 modules/11 posts))
= 0.0087 worker hours per module

Worker hours per FSLR4 module for installation of bearings and tubes (including squeeze splices) including movement of materials from staging area:
= (8 workers x 8 hours) /
(963 posts x (180 modules/11 posts)) = 0.0041 worker hours per module

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

In a typical representative time study, workers preassembled wind plate and small module and two purlins all together. One operator and two additional workers staged 132 sets of drive arms, actuators and small solar modules assemblies in 2 hours with one lull. 8 workers did preassembly of small solar modules and installed all components in this task on 132 tables in one day. A typical average number of silicon modules is 84 for one table, average number of FSLR4 modules is 180.

Worker hours per silicon module equivalent for installation of driving arms, small solar modules and actuators including movement of materials from staging area:
= (8 workers x 8 hours plus 3 workers x 2 hours) /
(132 tables x 84 modules per table) = 0.0063 worker hours per module

Worker hours per FSLR4 module equivalent for installation of driving arms, small solar modules and actuators including movement of materials from staging area:
= (8 workers x 8 hours plus 3 workers x 2 hours) / (132 tables x 180 modules per table) = 0.0029 worker hours per module

Task 4: Mounting of Purlins

In a typical relevant time study, 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 torqued to specification. 3 workers in 1 day mounted 500 purlins. Movement of 5016 purlins and hardware from staging area to field was completed in one day with one skid steer, one operator and two workers. One purlin is required per silicon module. Two purlins are required for every three FSLR4 modules in a typical 3 up landscape configuration. The purlins require two U bolts for FSLR4 modules vs 1 U bolt for silicon modules, so an estimated 25% increase in installation time is added to compensate for this factor.

Worker hours per silicon module equivalent for mounting of purlins including movement of materials from staging area:
= (3 workers x 8 hours)/ 500 modules + (3 workers x 8 hours) / 5016 modules = 0.0528 worker hours

Worker hours per FSLR4 module equivalent for mounting of purlins including movement of materials from staging area:
= ((3 workers x 8 hours) x (2/3) x (1.25)) / 500 modules +
((3 workers x 8 hours) x (2/3) x (1.25))/ 5016 modules = 0.0440 worker hours

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Task 5: Mounting of PV Modules with Star Washers for Bonding

This task consists of mounting purlin and modules. In the case of silicon modules in a typical relevant time study, each was mounted using four ¼-20 x ¾ inch long hex bolts, four serrated head flange nuts, plus one location with a star washer. After pushing bolt through purlin and panel frame, put star washer onto bolt inside panel frame, then put on the flange nut and torque bolt to specification. A four worker and one operator team used one skid steer to move modules from staging area, mount 500 modules per day, and remove boxes from field and place into dumpster. In the case of FSLR4 modules three modules are typically mounted on two purlins using 4 mid clips, 4 end clips, 8 self locking T bolts and 8 serrated flange nuts. A four worker and one operator team uses one skid steer to move modules from staging area, and would mount them at an estimated 1,000 modules per day, and remove boxes from field and place into dumpster.

Worker hours per module equivalent for mounting of silicon PV modules including movement of materials from staging area:
= (5 workers x 8 hours) / 500 modules = .0800 worker hours per module

Worker hours per module equivalent for mounting of FSLR4 PV modules including movement of materials from staging area:
= (5 workers x 8 hours) / 1,000 modules = .0400 worker hours per module

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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 module. A two worker team installed the master controllers in two hours. Each master covers an average of 175 node controllers. A typical table with one node controller has 84 silicon modules or 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 worker x 8 hours) / (40 controllers x 84 modules per controller) + (2 workers x 2 hours) / (1 master controller x 175 node controllers x 84 modules) = .0027 worker hours per module

Worker hours per silicon module equivalent for installation of controllers and the master controller including movement of materials from staging area:
= (1 worker x 8 hours) / (40 controllers x 180 modules per controller) + (2 workers x 2 hours) / (1 master controller x 175 node controllers x 180 modules) = .0012 worker hours per module