

GENIUS TRACKER™ SYSTEM INSTALL FIRST SOLAR SERIES 6™ MODULES WITH PREASSEMBLED SPEEDCLAMPS™

Task	Total Worker Hours Per Module
Staging of Posts	0.0036
Installation of Posts	0.0162
Installation of Bearings, Tubes, and Preassembled SpeedClamps™ Including Staging	0.0161
Staging of Preassembled Driving Arms, Actuators and Charging Modules	0.0015
Installation of Preassembled Driving Arms, Actuators and Charging Modules Including Staging	0.0032
Staging of PV Modules	0.0032
Mounting of PV Modules	0.0258
Installation of Controllers and Master Controllers	0.0032

Modules: 445 Watt First Solar Series 6™ framed modules
Site Conditions: Flat to slightly rolling topography
Wind: 105 mph ASCE-10 **Snow:** 5 psf
Design Specifications: 100 MW, 52 degree ROM, 6' and 7' embedment depth for posts. Tables: 7% perimeter, 93% interior
 398.9 posts per MW, 5.7 panels per post, 67.7 modules per actuator . Each master controller covered an average of 14,635 modules.

STUDY RESULTS:

**Complete install rate including moving materials from staging area:
 .0728 worker hours per module equivalent**

Complete install rate with 20 workers per week: 4.88 MW

Module-only install rate: 310 modules per worker per day

ABOUT THE STUDY

Installation of the Genius Tracker™ System includes posts, bearings, tubes, driving arms, charging module, actuators, sliding preassembled SpeedClamp™ onto tubes, mounting of modules onto preassembled SpeedClamps™, 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 with preassembled SpeedClamps™. The study was conducted by interviewing site supervisors and other industry professionals regarding workplace production on hourly and daily basis with employees assigned to perform specific tasks as well as by timed studies of both GameChange Solar ("GCS") and other personnel observed. 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 GCS personnel for first time installers of GCS systems.

STUDY DETAILS

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

Task 1: Staging of Posts

This task consists of staging posts at marked locations throughout the site, then driving them. One team of two workers with an operator in a skid steer staged 2.5 MW of posts (969 posts supporting 5,488 modules) each 1.25 8 hour days.

Worker hours per module equivalent for moving materials from staging area:

$$= (2 \text{ workers} \times 8 \text{ hours} \times 1.25 \text{ days}) / (5,488 \text{ modules}) \\ = 0.0036 \text{ worker hours per module}$$

Task 2: Installation of Posts

One team of two workers utilizing a post driver installed 175 posts per day.

Worker hours per module equivalent for post installation:

$$= (2 \text{ workers} \times 8 \text{ hours}) / (175 \text{ posts} \times 5.66 \text{ average modules per post}) = 0.0162 \text{ worker hours per module}$$

Task 3: Installation of Bearings, Tubes, and Preassembled SpeedClamps™

Workers start with mounting the center saddle bracket and bearing, attach standard post saddle brackets and bearing bottoms. Next, a laser is used to align and then saddle brackets are torqued. Then, tubes and squeeze splices are installed followed by completion of bearing installation using top of bearing and capture rings. Tubes and bearings were staged by the crews as they were installed. Preassembled SpeedClamps™ were slid onto tubes prior to placement. Tubes supporting 3,975 modules were completed per day with 8 workers, including movement of material from staging area.

Worker hours per module equivalent for installation of bearings and tubes with preassembled SpeedClamps™ (including squeeze splices) with movement of materials from staging area:

$$= (8 \text{ workers} \times 8 \text{ hours}) / (3,975 \text{ modules}) \\ = 0.0161 \text{ worker hours per module}$$

Task 4: Staging of Preassembled Driving Arms, Actuators and Charging Modules

One operator and two additional workers staged an average of 61 sets of drive arms, actuators and small solar modules assemblies in 2 hours with one lull.

Worker hours per module equivalent for staging of driving arms, charging modules and actuators:

$$= (3 \text{ workers} \times 2 \text{ hours}) / (61 \text{ sets} \times 67.7 \text{ modules per set}) \\ = 0.0015 \text{ worker hours per module}$$

Task 5: Installation of Preassembled Driving Arms, Actuators and Charging Modules

2 workers installed each set of one preassembled driving arm, actuator and small charging module at an average rate of 6.5 minutes each.

Worker hours per module equivalent for installation of driving arms, charging modules and actuators:

$$= (2 \text{ workers} \times 6.5 \text{ minutes} / 60 \text{ minutes}) / (67.7 \text{ modules per actuator set}) = 0.0032 \text{ worker hours per module}$$

Task 6: Staging of PV Modules

One worker drives skidsteer and places module boxes. On average, this took 5 minutes per round trip and each box holds 26 modules.

Worker hours per module equivalent for movement of materials from staging area:

$$= (1 \text{ worker} \times 5 \text{ minutes} / 60 \text{ minutes}) / 26 \text{ modules} \\ = 0.0032 \text{ worker hours}$$

Task 7: Mounting of PV Modules

This task consists of mounting modules onto preassembled SpeedClamps™. Two workers carry the module to the tube. Then both workers insert align and insert the module into the SpeedClamp™. The third worker then drives the two nuts to attach the SpeedClamp™ onto tube which simultaneously attaches and grounds the module as the first two workers slide the next SpeedClamp™ onto the other side of the module. The third worker then does final torquing and torque marks the nuts as the first two workers walk to bring the next module. Total time per module averaged 31 seconds. This means that three workers install 930 modules per day, or 310 per day per worker.

Worker hours per module equivalent for mounting of PV modules:

$$= (3 \text{ workers} \times 31 \text{ seconds}) / (60 \text{ minutes} \times 60 \text{ minutes}) \\ / 1 \text{ module} = 0.0258 \text{ worker hours}$$

Task 8: 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 67.7 modules. A two-worker team installed the master controllers in two hours. Each master covered an average of 14,635 modules.

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

$$= (1 \text{ worker} \times 8 \text{ hours}) / (40 \text{ controllers} \times 67.7 \text{ modules per controller}) + (2 \text{ workers} \times 2 \text{ hours}) / (1 \text{ master controller} \times 14,635 \text{ modules per master controller}) \\ = .0032 \text{ worker hours per module}$$