

GENIUS TRACKER™ SYSTEM INSTALL WITH PREASSEMBLED SPEEDCLAMPS™

Task	Total Worker Hours Per Module
Staging of Posts	0.0030
Installation of Posts	0.0135
Installation of Bearings, Tubes, and Preassembled SpeedClamps™ Including Staging	0.0134
Staging of Preassembled Driving Arms, Actuators and Charging Modules	0.0012
Installation of Preassembled Driving Arms, Actuators and Charging Modules Including Staging	0.0027
Staging of PV Modules	0.0028
Mounting of PV Modules	0.0172
Installation of Controllers and Master Controllers	0.0027

Modules: Polysilicon framed modules 380 Watts

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

387.7 posts per MW, 6.8 modules per post, 81.2 modules per actuator. Each master controller covered an average of 17,544 modules.

STUDY RESULTS:

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

Complete install rate with 20 workers per week: 5.38 MW

Module-only install rate: 464 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 2.5MW of posts (969 posts supporting 6,579 modules) each 1.25 8 hour days.

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

$$= (2 \text{ workers} \times 8 \text{ hours} \times 1.25 \text{ days}) / (6579 \text{ modules})$$
$$= 0.003 \text{ worker hours per module}$$

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:

$$= (2 \text{ workers} \times 8 \text{ hours}) / (175 \text{ posts} \times 6.79 \text{ avg modules per post})$$
$$= 0.0135 \text{ worker hours per module}$$

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 4,765 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:

$$= (8 \text{ workers} \times 8 \text{ hours}) / (4,765 \text{ modules})$$
$$= 0.0134 \text{ worker hours per module}$$

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:

$$= (3 \text{ workers} \times 2 \text{ hours}) / (61 \text{ sets} \times 81.2 \text{ modules per set})$$
$$= 0.0012 \text{ worker hours per module}$$

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:

$$= (2 \text{ workers} \times 6.5 \text{ minutes}) / (81.2 \text{ modules per actuator set})$$
$$= 0.0027 \text{ worker hours per module}$$

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 30 modules.

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

$$= (1 \text{ worker} \times 5 \text{ minutes} / 60 \text{ minutes}) / 30 \text{ modules}$$
$$= 0.0028 \text{ worker hours}$$

Task 7: Mounting of PV Modules

This task consists of mounting modules onto preassembled SpeedClamps™. The first worker carries the module to the tube. Then both workers align and insert the module into the SpeedClamp™. The second worker drives the two nuts to attach the SpeedClamp™ onto tube which simultaneously attaches and grounds module as the first worker slides the next SpeedClamp™ onto the other side of the module. The second worker then does final torquing and torque marks nuts as first worker walks to bring the next module. Total time per module averaged 31 seconds. This means that two workers install 928 modules per day, or 464 per day per worker. Alternative method is to speed install rate by utilizing third worker to do the final torque and marking of nuts. For this study, the two-worker method was used.

Worker hours per module equivalent for mounting of PV modules:

$$= (2 \text{ workers} \times 31 \text{ seconds}) / 1 \text{ module}$$
$$= 0.0172 \text{ worker hours}$$

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 81.2 modules. A two-worker team installed the master controllers in two hours. Each master covered an average of 17,544 modules.

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

$$= (1 \text{ worker} \times 8 \text{ hours}) / (40 \text{ controllers} \times 81.2 \text{ modules per controller}) + (2 \text{ workers} \times 2 \text{ hours}) / (1 \text{ master controller} \times 17,544 \text{ modules per master controller})$$
$$= 0.0027 \text{ worker hours per module}$$