

## TIME STUDY: SILICON MODULE WITH SPEEDCLAMP™

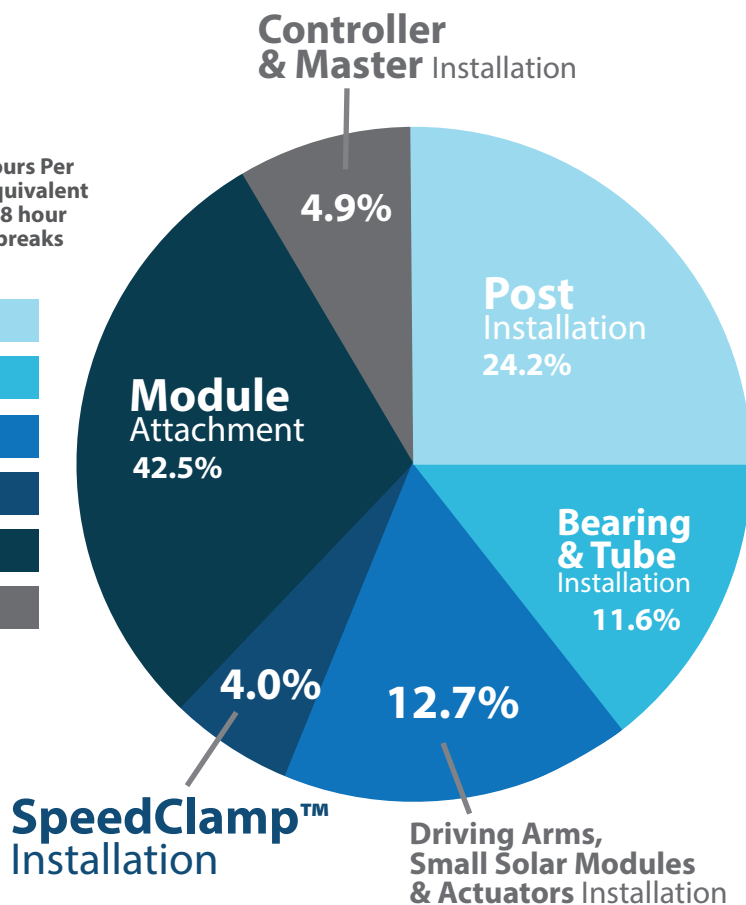
**Installer:** Composite installation rate data from three leading EPCs from multiple sites installed in USA in 2017 with Genius Tracker™ as well as analysis with leading EPCs of installation rates with similar module clamps with similar installation rate as preassembled GameChange SpeedClamp™.

**Location:** Typical California and Southeast Conditions

**Modules:** Silicon framed modules 350 Watts

**Site Conditions:** Slightly sloping to flat

	Worker Hours Per Module Equivalent (%)	Worker Hours Per MW (350W modules)	Worker Hours Per Module Equivalent (Based on 8 hour workday, breaks included)
Post Installation	24.2%	76	0.0266
Bearing & Tube Installation	11.6%	36	0.0128
Driving Arm, Small Solar Module & Actuator Install	12.7%	40	0.0140
SpeedClamp™ Installation	4.0%	13	0.0044
Module Attachment	42.5%	133	0.0467
Controller & Master Installation	4.9%	15	0.0054



## STUDY RESULTS

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

**.1098 worker hours per module equivalent including moving materials from staging area**

**2.551 MW system installation rate with 20 workers per week**

### ABOUT THE STUDY

Installation of posts, bearings & tubes, driving arms, small solar module & actuators, sliding SpeedClamp™ onto tubes, mounting of modules onto preassembled SpeedClamp™, 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 SpeedClamp™. 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.

## STUDY DETAILS

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

### Task 1: Installation of Posts

Taken from typical site installations for normal driving with normal refusal issues. This task consists of staging posts at market locations throughout the site, then driving them. One team of two workers with an operator in a skid steer staged posts over two full 8 hour days for piles for 5,016 modules. One team of two workers utilizing a pile driver installed 175 posts per day. Total number of posts were 2,546 for 16,201 modules.

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

$$= (2 \text{ workers} \times 8 \text{ hours}) / (120 \text{ posts} \times 5.208 \text{ average modules per post}) + (2 \text{ workers} \times 8 \text{ hours}) / (2,546 \text{ posts supporting } 16,201 \text{ modules}) = 0.0266 \text{ worker hours per module}$$

### Task 2: Installation of Bearings and Tubes

Workers started with mounting the center bearing and placing standard bearing bottoms on finger tight. Next, they used a jig made of a 6 inch outside diameter conduit cap, used a barrel laser to align, and then torqued the hardware holding the bottoms of bearings. Then, they installed tubes and squeeze splices. Lastly, they installed plastic halves, tops of bearings and screwed on the capture rings. Tubes and bearings were brought out by the crew as they were installed. 132 tables of 38 panels per table were completed in one day with 8 workers, including movement of material from staging area.

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

$$= (8 \text{ workers} \times 8 \text{ hours}) / (5,016 \text{ modules}) = 0.0128 \text{ worker hours per module}$$

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

Workers preassembled wind plate, 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 solar modules and installed all components in this task on 132 tables in one day.

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

$$= (8 \text{ workers} \times 8 \text{ hours plus } 3 \text{ workers} \times 2 \text{ hours}) / (5016 \text{ modules}) = 0.0140 \text{ worker hours per module}$$

### Task 4: Sliding SpeedClamp™ onto Tubes

Preassembled SpeedClamps™ are slid down tubes, left finger tight. Based on estimates from installation of similar system clamps used, using SpeedClamp™ only takes 10% of the time required for typical purlin/clamp installation.

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

$$= (5 \text{ workers} \times 8 \text{ hours} \times 10\%) / 900 \text{ modules} = 0.0044 \text{ worker hours}$$

### Task 5: Mounting of PV Modules

This task consists of mounting modules onto preassembled SpeedClamp™ with an additional five percent added for the four purlins with bottom mount bolt and serrated flange nut attachment method required at tracker ends and tracker center. 225 modules are estimated to be installed per worker per day plus added one full time operator with skid steer to stage 4 workers doing module installation.

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

$$= (5 \text{ workers} \times 8 \text{ hours} \times 105\%) / 900 \text{ modules} = 0.0467 \text{ worker hours}$$

### 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 covered an average of 5,629 modules.

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

$$= (1 \text{ worker} \times 8 \text{ hours}) / (40 \text{ controllers} \times 42.95 \text{ modules per controller}) + (2 \text{ workers} \times 2 \text{ hours}) / (1 \text{ master controller} \times 5,629 \text{ modules per master controller}) = 0.0054 \text{ worker hours per module}$$