

## MAXSPAN™ SYSTEM INSTALL WITH INTEGRATED-HARDWARE™ FOR MODULE MOUNTING

Task	Total Worker Hours Per Module
Staging of Posts	0.0012
Installation of Posts	0.0062
Staging of Racking	0.0022
Installation of Racking	0.0455
Staging of Modules	0.0076
Mounting of Modules	0.0558

Modules: Polysilicon framed modules 380 Watts  
 Site Conditions: Flat to slightly rolling topography  
 Wind: 97 mph ASCE-5 Snow: 15 psf  
 Design Specifications: 54.7 MW, 20 degree tilt, 5', 6' and 8.5' embedment depth for posts. 251.4 posts per MW average

### STUDY RESULTS:

**Complete install rate including moving materials from staging area:  
 .1172 worker hours per module equivalent  
 Complete install rate with 20 workers per week: 2.204 MW**

#### ABOUT THE STUDY

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 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 a 6.8 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.

Installation of the MaxSpan™ System included installation of posts, racking, and mounting of modules. A previously conducted time study from a group of projects totaling 54.7 MW was utilized for the installation rates for posts and racking. The study was adjusted to actual rates derived from a timed installation under similar working conditions for module installation reflecting time savings from utilizing Integrated-Hardware™ for module mounting, which include self-grounding oversized flange bolts with integrated teeth, eliminating need for star washers (for grounding) and washers (if used) as well as oversized serrated flange nuts to eliminate the need for washers (if used). In addition, the per MW installation rates have been adjusted as if using current 380 watt modules.

## STUDY DETAILS

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

### Task 1: Staging of Posts

This task consists of staging channel posts at marked locations throughout the site. One team of three workers conducted layout of 1,300 posts per 6.8 hour work day with one worker driving tracked skidsteer backwards and the other two workers unloading posts at rooster tail flag locations.

Worker hours per module equivalent for post, which supported 13.443 modules average:

$$= (3 \text{ workers} \times 6.8 \text{ hours} \times 244.8/1,300) / (244.8 \text{ posts} \times 13.443 \text{ modules per post}) = 0.0012 \text{ worker hours per module equivalent}$$

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### Task 2: Installation of Posts

This task consists of driving channel posts at marked locations on the site. One pile driving machine operator and two workers drove posts at rooster tail flag locations and moved to the next post location at the rate of 1 minute and 40 seconds per post average, or 244.8 per 6.8 hour work day.

Worker hours per module equivalent for post, which supported 13.443 modules average:

$$= (3 \text{ workers} \times 6.8 \text{ hours}) / (244.8 \text{ posts} \times 13.443 \text{ modules per post}) = 0.0062 \text{ worker hours per module equivalent}$$

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### Task 3: Staging of Racking

This task consists of staging racking at marked locations throughout the site. One team of three workers placed 640 beams and braces in half of one 6.8 hour work day with one worker driving tracked skidsteer backwards and the other two workers unloading piles at post locations. In addition, one team of three workers were able to layout 6 MW (20,275.5 module equivalents) of purlins, purlin angles and other components in one 6.8 hour work day with one worker driving tracked skidsteer backwards and the other two workers unloading between post locations.

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

$$= (3 \text{ workers} \times 3.4 \text{ hours}) / (640 \times 13.443 \text{ modules}) + (3 \text{ workers} \times 6.8 \text{ hours}) / (20275.5 \text{ modules}) = .0022 \text{ worker hours}$$

### Task 4: Installation of Racking

Two worker crews installed 640 sets of beams and braces per 6.8 hour workday (8,603.7 module equivalents). Six four worker crews installed 1.1 MW (3,717 module equivalents) per day purlins, purlin angles and other components. The first crew attached purlins as the next crew attached purlin angles and other components finger tight. The final crew performed alignment, squaring, torque to specification, and torque marking.

Worker hours per module equivalent for installation of racking:

$$= (2 \text{ workers} \times 6.8 \text{ hours}) / (8,603.7 \text{ modules}) + (24 \text{ workers} \times 6.8 \text{ hours}) / (3,717 \text{ modules}) = .0455 \text{ worker hours}$$

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### Task 5: Staging of Modules

This task consists of staging modules from staging area. Staging of modules took .0189 worker hours based on 10% of total time for staging and installation.

Worker hours per module equivalent for staging of modules:

$$= (24 \text{ workers} \times 6.8 \text{ hours} \times 10\%) / (2,160 \text{ modules}) = 0.0076 \text{ worker hours}$$

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### Task 6: Mounting of Modules

This task consists of mounting modules onto purlins. This included inserting the bolt from below the purlin, through the module frame, and then placing the star washer on the bolt. The next step was placing the serrated flange nut on bolt, holding the nut with finger to attach the bolt to rated torque with driver. For the other three locations per module, this procedure was conducted without using the star washer. The final step would require a QC team to follow and check every bolt with the torque wrench to make sure to specification, and then add torque mark with black Sharpie. A 24 worker crew completed the installation of the 2,160 modules per day, working 6.8 hours per day actual work rate which was equal to 3.778 min per worker per module including staging which took 10% of the total time. Utilizing Integrated-Hardware™ with grounding teeth eliminated star washers which reduced the installation time to 3.100 minutes per worker per module.

Worker hours per module equivalent for mounting of PV modules:

$$= (24 \text{ workers} \times 6.8 \text{ hours} \times .9 / 2,160 \text{ modules}) \times (3.100 \text{ minutes} / 3.778 \text{ minutes}) = 0.0558 \text{ worker hours}$$