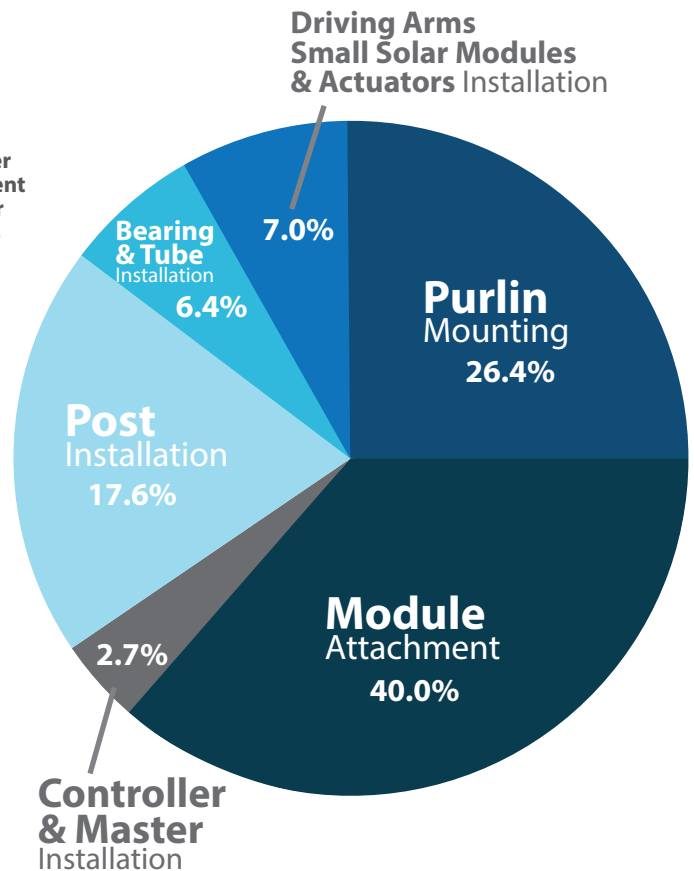


TIME STUDY: SILICON MODULE WITH PURLINS

System Size: 23.84MW in a group of 14 projects
Genius Tracker™ System (Single axis tracker)
Location: Georgia
Installer: Leading Regional EPC
Installer familiarity with System: First time
Time frame: October 2016 to May 2017

Modules: Silicon modules ranging from 255 to 320 watts, averaging 302.5 watts
Site Conditions: Mostly sloping. Sites had hard red clay which made pile driving very slow compared to average sites
Weather Conditions: Seasonally normal for regional, periods of rain

	Worker Hours Per Module Equivalent (%)	Worker Hours Per MW (345W modules)	Worker Hours Per Module Equivalent (Based on 8 hour workday, breaks included)
Post Installation	17.6%	116	0.0352
Bearing & Tube Installation	6.4%	42	0.0128
Driving Arm, Small Solar Module & Actuator Install	7.0%	46	0.0140
Purlin Mounting	26.4%	174	0.0528
Module Attachment	40.0%	264	0.0800
Controller & Master Installation	2.7%	18	0.0054



STUDY RESULTS

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

.200 worker hours per module equivalent including moving materials from staging area
1.210 MW system installation rate with 20 workers per week

ABOUT THE STUDY

Installation of posts, bearings, row tubes, purlins, driving arms, actuators, mounting of PV modules with star washers for bonding, wind deflectors with small solar modules, 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. 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. 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

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 posts over two full 8 hour days for entire site of 5016 modules. Another team of two workers with a pile driver drove 120 posts per day. Sites had hard red clay which made pile driving very slow compared to average sites.

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

$$= (2 \text{ workers} \times 8 \text{ hours}) / (120 \text{ posts} \times 5.208 \text{ average modules per post}) + (3 \text{ workers} \times 8 \text{ hours} \times 2 \text{ days}) / 5016 \text{ modules} = .0352 \text{ worker hours per module}$$

Task 2: Installation of Bearings and Tubes

Workers started with mounting the center bearing, then put standard bearing bottoms on finger tight. Next, they used a jig made of a 6 inch outside diameter conduit cap and then used a barrel laser to align. Then they torqued the bottom of the bearing, installed tubes, squeeze splices, plastic halves, top of bearing and then screw in 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 module assemblies in 2 hours with one lull. 8 workers would preassemble wind plate, small module with two purlins and installed all components in this task on 132 tables within 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: Mounting of Purlins

Purlins and hardware were placed onto tubes finger tight by two workers. Then, the 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 5,016 purlins and hardware from staging area to field was completed in one day using one skid steer with an operator and two workers.

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

$$= (3 \text{ workers} \times 8 \text{ hours}) / 500 \text{ modules} + (3 \text{ workers} \times 8 \text{ hours}) / 5016 \text{ modules} = 0.0528 \text{ worker hours}$$

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

This task consists of mounting purlins and modules each 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, place star washer onto bolt inside panel frame. Then put on the flange nut and torque bolt to specification. A team of four workers with one operator for skid steer were used to move modules from staging area, mount 500 modules per day, remove boxes from field and place into dumpster.

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

$$= (5 \text{ workers} \times 8 \text{ hours}) / 500 \text{ modules} = .0800 \text{ worker hours per module}$$

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 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:

$$= (1 \text{ worker} \times 8 \text{ hours}) / (40 \text{ controllers} \times 42.95 \text{ modules per controller}) + (2 \text{ workers} \times 2 \text{ hours}) / (1 \text{ master controller} \times 5,629 \text{ modules per master controller}) = .0054 \text{ worker hours per module}$$