

PRELIMINARY

Tensioned Cable System (TCS)

Installation

MANUAL

For Implementing
Solar Panel Mounting Kits

(TCS-R1-###)

(TCS-R2-##x#)

(TCS-G1-#-##)

(TCS-G2-1-##)

REV NEW Draft 8/26/11

Technical Support: (360) 301-5133

www.olympicenergysystems.com



Roof Mount Kit
(Example)

Pre Release Copy



Roof



Ground

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Introduction

This manual is intended for use by purchasers, users, and installers of the Tensioned Cable System solar panel mounting kits that use tensioned cables and no roof penetrations and no ground foundations.

As with any alternative to a conventional product or technique, there is a learning curve. The learning curve around tensioned cables is “f-a-s-t-e-n-a-t-i-n-g”, as there are insights revealed once the principles are understood.

Site Assessment

Solar Access (percentage of annual energy captured)

Mounting Surface or Area

Integration with Site Electrical Supply (for grid-tie applications)

Patent Pending – Key Attributes

Tensioned Cables Solar Panel Mounting System (Roof Mount) patent application filed March 15, 2010, with the following key attributes:

Tensioned Cables

Gable Mount (“C” Mount)

Eave Mount (similar to Gable Mount)

Pivot Joint

Lift Tensioner

PV Clamp Mid and End)

Rails (off the shelf) used in conjunction with Tensioned Cables

Dual Opposing Catenary Solar Panel Mounting System (Ground Mount) patent application filed March 15, 2011, with the following key attributes:

Tensioned Cables

Dual Opposing Catenary (Cables)

Thrust Plates with Integral Tensioning

Stanchion Geometry for Stability held down via Earth Anchors

PV Clamp (Dual - PV and Cable)

TCS System Description

Mounting Kits are available for roof and ground mounting of framed solar panels. Design evolution will eventually take us to mounting thin film PV without frames. This is part of an anticipated Design Science leading us to do more with less.

Tensioned cables in roof mount systems (R1 and R2) have a “hold down” role, with much of the panel and rail weight supported by Peak Mounts that “hook” onto the peak. Bulk tensioning is provided by Lift Tensioners on the surface of the roof. Fine tensioning is provided by Pull Tensioners attached to the C-shaped C-rings of the Gable Mount.

Tensioned cables in ground mount systems (G1 and G2) have a “hold-up” role, with tensioned cables holding up significant weight, and with an exposure to wind, necessitating dual opposing cables to provide stability. The shape, size, and geometry of the stanchions also provide stability, especially in winds. Integral tensioning is provided by eye bolts in the Thrust Plates on the end stanchions. End cables attached to earth anchors include turnbuckles, a form of Lift Tensioner that allows a balancing between the suspended PV cables and the end cables, ensuring that stanchions remain vertical and firm.

In all systems, PV panels are held firm by PV Clamps, with fasteners that attach to rails on the roof and cables on the ground.

Olympic Energy Systems, Inc.

TCS System Specification

(Derived from TCS Selection Guide)

(The Guide will be phased out, with the Manual providing support for all project phases.)

TCSPMS – Tensioned Cable Solar Panel Mounting System

Developed by Olympic Energy Systems, Inc. Port Townsend, WA 98368

TCS Specification REV DRAFT – Preliminary

August 26, 2011

Introduction

The Tensioned Cable System (TCS) provides a means for low cost mounting of solar panels on roofs without penetrations and on the ground without foundations. The key to doing more mounting with less material is tensioned cables. Cost reductions over conventional means are a result of reduced material content and simplified installation steps. The design is covered by patent applications in 2010 and 2011, via Patent Attorney Virginia P. Shogren, P.C., of Sequim, Washington at (360) 461-5551.

The mounting system shall accommodate the installation of at least one string (for grid-tie) for any framed photovoltaic (PV) panel on the commercial market, totaling at least 20 manufacturers and hundreds of different sizes and electrical outputs.

Roof Mount

The basic roof mount system – initially a gable to gable design, with eave to eave versions reserved for future commercial development - shall consist of the following components:

Hold Down Cables (1/4" Stainless Steel)

Cable Hardware (Clips, Thimbles, and Crimps)

Gable Mounts

Peak Mounts (w/ Hold Down)

Pull Tensioners

Lift Tensioners

PV Retention Clips

Rails (Uni-Strut, shallow)

Rail Plates (Joints)

Pivot Joints (under Gable ends) or upon Gable Trim (using the Universal Pivot Joint)

PV Clamps (both Mid and End)

Fasteners (Machine & Lag Bolts, Spring Nuts, Hex Nuts, Lock Nuts, Eye Bolts, and Washers)

Note: PV Panels and wiring not provided

All material shall be either Galvanized Steel, Painted Steel, Stainless Steel, or Aluminum, with allowance for enamel paint and surface protectors. Materials shall be suitable for outdoor environments and shall not be hazardous.

Ground Mount

The basic ground mount system shall consist of the following components:

PV and End Cables (1/4" Stainless Steel) and Cable Hardware (Clips, Thimbles, and Crimps)
Stanchion Mounts (End and Mid) w/ Cross Support Member
Tension Plates
Earth Anchors (40" minimum)
Turnbuckle Tensioners (End Cables)
Pull Tensioners (PV Cables)
Cross Ties (between parallel cables) - Straps held permanent with Pop Rivets
PV Cable Clamps (Mid and End)
Pier Block Surface Bases (on Ground)
Keeper Hardware (Mid Stanchion) and Fasteners (hex head screws, nails)

All metallic materials shall be either Galvanized Steel, Painted Steel, Stainless Steel, or Aluminum. Stanchions may be fabricated from Treated Lumber or other suitable materials for strength, longevity, and environmental compatibility. Materials shall be suitable for outdoors and shall not be hazardous.

System Kits

The basic mounting systems (roof and ground) shall be pre-fabricated and available in kits. System designs shall provide for a pair and a string of framed PV Panels. For roof mount systems, there shall be accommodation for variations of landscape or portrait orientations of different size rows and columns.

Part Numbering

The format of the roof mount part number (aka System Definition Number) shall be **OES-TCS-R1-nxmabbc-ddd-PV Model #**, where n = number of rows, m = number of columns, a = Orientation L or P, bb = pitch ##/12, c = Overhang Y or N, ddd = number of inches from gable to gable (Roof Width), and PV Model # is the manufacturer model number for individual PV panels selected. R1 is the first version.

The format of the ground mount part number shall be **OES-TCS-G1-y-zz**, where y = number of spans 1 or 2, and zz = nominal span length 10, 12, 14, 16, or 18 [in feet]. As the length is encoded in the selected dash number zz, no PV Model # is required, though contemplated when ordering. G1 is the first version.

Installation Support

Background, tips, drawings, pictures, and steps in the installation and maintenance of the TCS mounting systems should be included in an Owner Manual. Replacement component parts, with part numbers, will be available. Design, selection, and installation inquiries may be directed to Jonathan A. Clemens, President, Olympic Energy Systems, Inc. at (360) 301-5133.

TCS Mounting Kit Selection

(Derived from TCS Selection Guide)

Safety Precautions

Proper use and handling of ladders is required. Activity on roofs may require use of safety harnesses and cables. Caution must be used around electrical devices, including solar panels which are active – with high voltage DC - anytime they are exposed to sunlight. Mounting hardware is metallic and may have sharp edges. Personnel should avoid standing on mounting hardware and/or installed solar panels. Installation should not be attempted without knowledge of proper safety precautions and techniques.

Skills Required

Installation requires use of basic hand tools and a drill (for pivot joint installation). Knowledge of measuring and layout (for locating pivot joints and thus the hold down cables and PV array) is essential.

Tools Needed

No special tools are needed, except that a Crimping Tool may be needed to secure cable ends (optional). Cables are provided, via customer specification, at the required length, precluding having to cut cable (wire rope). A cable or bolt cutter, or circular grinder, may be used to cut cable. Necessary hand tools:

Open Ended (or Box) Wrench Set

Socket Wrench Set

Drill w/ Bits

Pliers (optional) [Pop Riveter needed to secure Cross Ties in G1 and G2 systems]

Note: Rail length provided in the kits is adjustable without cutting; a saw is not needed.

How to use this Guide

Sizing of solar electric systems depends on a number of factors, including the site characteristics, roof dimensions, economic conditions, owner budget, aesthetics, and equipment availability. Though the mounting systems herein are specified as kits, one should not assume that system design and sizing is merely a prescriptive process. There is always more than one way to implement a solar electric system, thus, several options should be explored, even beyond the charts and tables. Solar PV panels can be mounted in portrait or landscape orientation and in many different combinations of rows and columns to achieve minimal string size for tying to the electric grid.

Tables and figures in the manual allow a quick lookup of the wide range of PV array sizes and shapes. One could start with a system output value (i.e., wattage) and derive the kits that allow mounting, or one could look at the mounting specification and derive a system size. Embedded in the selection data are constraints of PV panel size (height and width) and open circuit voltage - key drivers in the mounting system design. The array voltage and power must meet minimal requirements of the inverter tying the DC energy of the PV panels to the AC of the electric grid. Use the guide as a reference and use diligence as a means of assuring the most appropriate system for the new owner.

Assembly (from Kits)

All hardware needed to mount the specified number of solar panels on roofs is included in the R1 and R2 Kits, except for the shallow Uni-Strut rail. Rails are mounted vertically up and down the roof (V-Rails) – connected to the Peak Mounts – and mounted horizontally left to right (H-Rails), without lag bolts and penetrations through the roof. The preferred or common orientation of solar panels is Portrait, though Landscape is available with very similar kits. Component parts can be procured separately, allowing for customer specified kits, allowing more versatility in roof layout and system size. Uni-Strut rail is available in most hardware and building supply stores and certainly at all electrical distributors.

The variability from small system kits (1A, 1B, etc.) to large kits (2E, 3A, etc.) is simply the different quantity of Peak Mounts, Fasteners, PV Clamps, and Rails needed. Each kit (and associated kit number K###) expands through the addition of a fixed amount of Peak Mounts and Rails, allowing longer rows or additional rows beneath the first. Rail length is extended by concatenating rails using rail plates that act as splices or joints. Specific rail length is achieved by adjusting the relative position of the added rail, then securing it with rail plates. Hold down is assured via cables secured to the gable underside by Gable Mounts, per a patent pending approach. Pull and Lift Tensioners in kits allow cable tensioning. Ground mount kits vary in the length of cables, size (length) of earth anchors, and quantity of PV clamps.

R1 Kits

R1 kits mount solar PV panels in portrait or landscape on a roof with a grid of shallow Uni-Strut rails, hung from peak mounts and held down with tensioned cables running gable to gable. Peak mounts are placed at 6 foot intervals. PV panels mount on horizontal rails, which in turn mount on vertical rails in contact with the roof surface. All hardware, except rails, is included in kits. Part Number *Example*: TCS-R1-P2D = Roof Mount, Portrait, 2 Row, Size D (5 Peak Mounts)

R2 Kits

R2 kits mount solar PV panels in portrait or landscape on a roof with a grid of shallow Uni-Strut rails, organized by columns, hung from peak mounts and held down with tensioned cables running gable to gable. Peak mounts are placed at every column, i.e., at each PV panel (centered). In landscape, PV panels mount on vertical rails set directly on the roof, thus, the panels are closer to the roof surface than those mounted in portrait. All hardware, except rails, is included in kits. Part Number *Example*: TCS-R2-P3x8 = Roof Mount, Portrait, 3 Row, 8 Column (8 Peak Mounts)

G1 Kits

G1 kits mount a string of solar PV panels in Portrait on the ground with tensioned cables strung between stanchions, for a single row, held to the ground with cables attached to earth anchors. Integral pull tensioners provide for tensioning of PV cables. All hardware is included in kits. Part Number *Example*: TCS-G1-2-12 = Ground Mount, 2 Span (w/ mid-stanchion), 12 feet nominal per Span

G2 Kits

G2 kits mount a string of solar PV panels in Portrait on the ground with tensioned cables strung between two sets of two stanchions, **forming two independent rows (a first and second tier)**, held to the ground with cables attached to earth anchors. Integral pull tensioners provide for tensioning of PV cables. All hardware is included in kits. Part Number *Example*:

TCS-G2-1-10 = Ground Mount, 1 Span (two rows), 10 feet nominal per Span

The G2 is essentially two G1 units without the mid-stanchions, with the rear tier on higher posts, and placed as two rows one in front of the other (to form a single PV string) at a spacing between rows of about 20 inches (to allow personnel access for installation and maintenance). The G2 reduces the ground mount footprint width from about 35 feet with the G1 to about 16 feet with the G2, with an accompanying footprint depth increase from about 5 feet to 10 feet.

The G2 is used where land space will not allow the longer length of the G1, otherwise, the G2 mounts the same number of PV panels as the G1.

PROCESS: Customer decides on SIZE (Wattage) and provides Roof Parameters via a System Definition Number (SDN), per the included SDN Chart. **OES derives the KIT No. from the SDN.**

Kits contain ALL hardware to mount solar PV panels, except shallow Uni-Strut Rails available from contractor supply houses or hardware stores. See Appendix for **TCS Specification** details. **R1-P Kit** sizes:

1A = 1 Row w/ 2 Peak Mounts **1B** = 1 Row w/ 3 Peak Mounts ... **3E** = 3 Rows w/ 5 Peak Mounts

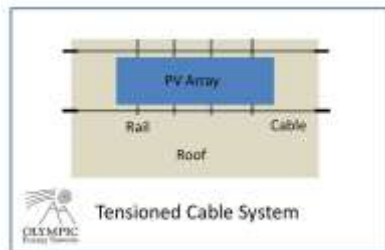
The Rail Length may be reduced (up to 4 feet – by adjusting the joint and without cutting the rails) to accommodate fewer or smaller panels, except A Kits.

Mounting KIT: OES Item No. TCS-R1-P1A through 3E

SIZING CHART

KIT TCS-R1- K##	URA Usable Rail AREA H x W (Feet) "PV Footprint"	URL Usable Rail LENGTH Feet (inches) Usable PV Width	Quantity	Quantity	Solar Panels: [Make & Model]
			10 foot (Shallow) Uni-Strut Rails (PORTRAIT) n = 6'S = 6 foot	10 foot (Shallow) Uni-Strut Rails (LANDSCAPE) n = 6'S = 6 foot	
1A	7 x 9-1/2	9-1/2 (114 in.)	4 (2 + 2[6'S])	2 + 2[6'S]	R1 Kits Chart
1B	7 x 15-1/2	15-1/2 (186 in.)	7 (4 + 3[6'S])	4 + 3[6'S]	R1 Kits Chart
1C	7 x 21-1/2	21-1/2 (258 in.)	10 (6 + 4[6'S])	6 + 4[6'S]	R1 Kits Chart
1D	7 x 27-1/2	27-1/2 (330 in.)	13 (8 + 5[6'S])	8 + 5[6'S]	R1 Kits Chart
1E	7 x 33-1/2	33-1/2 (402 in.)	16 (10 + 6[6'S])	10 + 6[6'S]	R1 Kits Chart
2A	11 x 9-1/2	19	8 (6 + 2[6'S])	6	R1 Kits Chart
2B	11 x 15-1/2	31	14 (11 + 3[6'S])	11	R1 Kits Chart
2C	11 x 21-1/2	43	20 (16 + 4[6'S])	16	R1 Kits Chart
2D	11 x 27-1/2	55	26 (21 + 5[6'S])	21	R1 Kits Chart
2E	11 x 33-1/2	67	32 (26 + 6[6'S])	26	R1 Kits Chart
3A	16-1/2 x 9-1/2	28-1/2	10	8 + 2[6'S]	R1 Kits Chart
3B	16-1/2 x 15-1/2	46-1/2	18	15 + 3[6'S]	R1 Kits Chart
3C	16-1/2 x 21-1/2	64-1/2	26	22 + 4[6'S]	R1 Kits Chart
3D	16-1/2 x 27-1/2	82-1/2	34	29 + 5[6'S]	R1 Kits Chart
3E	16-1/2 x 33-1/2	100-1/2	42	36 + 6[6'S]	R1 Kits Chart

Table - R1 Kit DEFINITION



Basic Architecture



Small 1x2P with (2) Peak Mounts

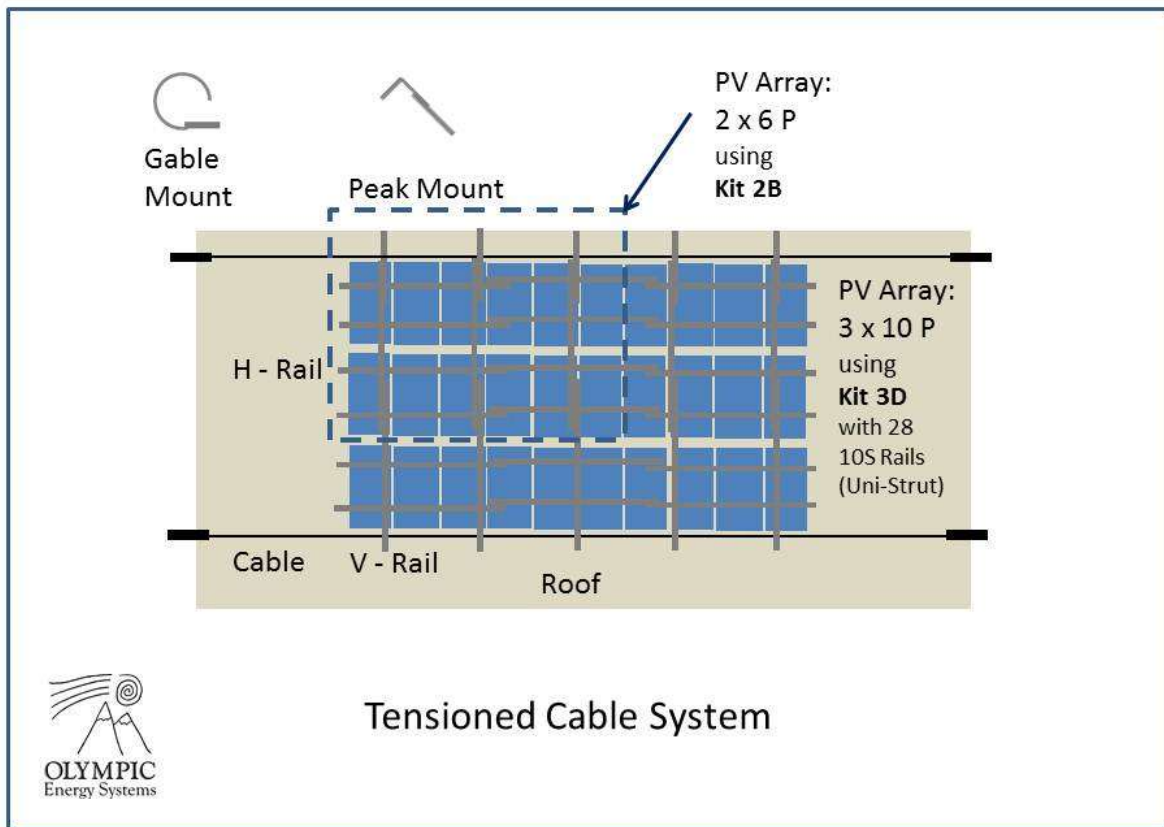


Figure – R1 Component Layout [PORTRAIT]

Determination of Kit Size (1A through 3E) [Portrait]

- 1) Determine the $n \times m$ array configuration (to give the desired power output) for the particular chosen PV panel (Solar World, or Sanyo, etc.) – the **R1 Kit Chart** can be used to directly select the Kit Number, OR
- 2) Determine Usable Rail Area (URA), i.e., the PV footprint of the array configuration, using the published dimensions of the PV panel
- 3) Determine Usable Rail Length (URL) for a single row based on the PV panel width – this determines the A-E designation in the Kit Number
- 4) Select the Kit Number providing the URL and best matching the URA

Note: The number of PV panels per row can be shortened by one PV panel width to meet the desired number of panels per row. Always choose the Kit with a number per row greater than or equal to the desired number of PV panels per row.

R1 KIT: OES Item No. TCS-R1-P1A through K3E NUMBER OF PV PANELS per KIT [Portrait]

Model No.	1A	1B	1C	1D	1E	2A	2B	2C	2D	2E	3A	3B	3C	3D	3E	Power Kit 3E
BP Solar BP3200B	3	5	7	9	12	6	10	14	18	24	9	15	21	27	36	7.2 KW
Canadian CS6A-150	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	4.5 KW
Day4 48MC-190	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	5.7 KW
ET Solar P654200	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	6.0 KW
Evergreen ES180	3	4	6	8	10	6	8	12	16	20	9	12	18	24	30	5.4 KW
Evergreen ES-A-200	3	4	6	8	10	6	8	12	16	20	9	12	18	24	30	6.0 KW
GE Vp200MSA	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	6.0 KW
Kaneka G-SA060	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	1.8 KW
Kyocera KD130SX	4	6	9	12	15	8	12	18	24	30	12	18	27	36	45	5.85 KW
Mitsubishi PV-UE-120	4	6	9	12	15	8	12	18	24	30	12	18	27	36	45	5.4 KW
REC Solar SCM210	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	6.3 KW
Sanyo HIT Power 200	3	5	7	9	11	6	10	14	18	22	9	15	21	27	33	6.6 KW
Schott ASE250	2	3	5	6	7	4	6	10	12	14	6	9	15	18	21	5.25 KW
Schuco S320-PM	2	3	5	6	8	4	6	10	12	16	6	9	15	18	24	7.68 KW
Sharp ND-130	4	7	9	12	15	8	14	18	24	30	12	21	27	36	45	5.85 KW
SolarWorld SW175	3	5	8	10	12	6	10	16	20	24	9	15	24	30	36	6.3 KW
Sun Power SPR210BLK	3	5	8	10	12	6	10	16	20	24	9	15	24	30	36	7.56 KW
Suntech STP-200-18	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	6.0 KW
Trina 180-DC01	3	5	7	10	12	6	10	14	20	24	9	15	21	30	36	6.48 KW
XC3 Int.I XCI300-130	4	7	9	12	15	8	14	18	24	30	12	21	27	36	45	5.85 KW
Yingli YL175	2	4	6	8	10	4	8	12	16	20	6	12	18	24	30	5.25 KW

Table – R1 Kit Selection Chart

Olympic Energy Systems, Inc.

SIZE n x m	# Peak Mounts	# Lift Tensioners	Quantity 10S Rail	Quantity 6S Rail
1x3	3	6	2	3
1x4	4	8	4	4
1x5	5	10	4	5
1x6	6	12	4	6
1x7	7	14	6	7
1x8	8	16	6	8
1x9*	9	18	6	9
1x10	10	20	8	10
1x11	11	22	8	11
1x12*	12	24	8	12
1x13	13	26	10	13
1x14	14	28	10	14
1x15*	15	30	10	15
2x3	3	6	7(10)	3(0)
2x4	4	8	12(16)	4(0)
2x5	5	10	13(18)	5(0)
2x6	6	12	14(20)	6(0)
2x7	7	14	19(26)	7(0)
2x8	8	16	20(28)	8(0)
2x9*	9	18	21(30)	9(0)
2x10	10	20	26(36)	10(0)
2x11	11	22	27(38)	11(0)
2x12*	12	24	28(40)	12(0)
2x13	13	26	33(46)	13(0)
2x14	14	28	34(48)	14(0)
2x15*	15	30	35(50)	15(0)
3x3	3	6	12	0
3x4	4	8	20	0
3x5	5	10	22	0
3x6	6	12	24	0
3x7	7	14	32	0
3x8	8	16	34	0
3x9*	9	18	36	0
3x10	10	20	44	0
3x11	11	22	46	0
3x12*	12	24	48	0
3x13	13	26	56	0
3x14	14	28	58	0
3x15*	15	30	60	0

Table – R2 Kit DEFINITION [PORTRAIT]

*PV Panel Width 36” max

Note: PV Panel Height = 70” max for 3 Row configuration.

Lift Tensioners require only a minimum number of tensioning eyebolts; o/w cable passes through.

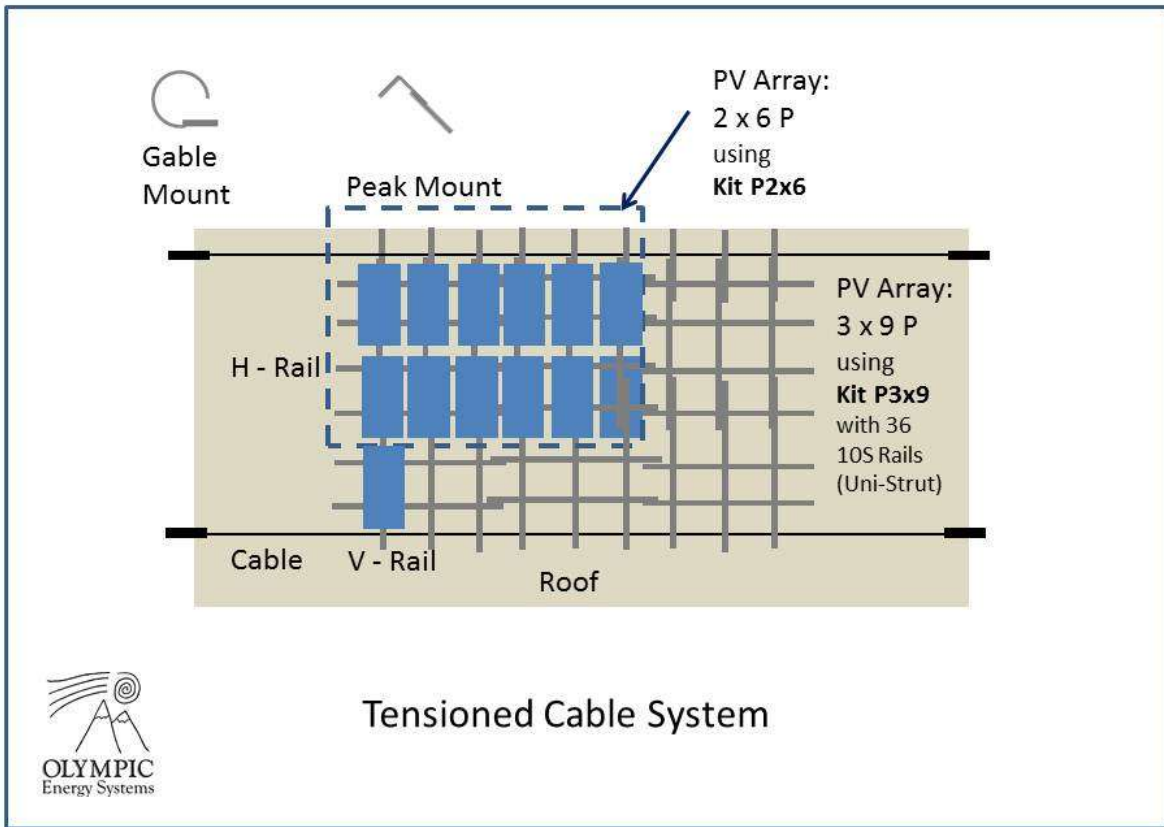


Figure – R2 Component Layout [PORTRAIT]

The R2 Kit tends to be simpler to lay out and install than the R1 Kit. The R2 Kit uses more rails than the R1 Kit, but the marginal cost is more than offset by the benefits of simplicity and added strength to the installation. More choices in layouts mean flexibility to handle roof constraints and obstacles.

For installers, these mounting kits offer a relatively unknown feature, in that solar panels actually rest on retaining clips before being clamped to the rails, offering a safer installation and extra security against loss of clamping force. The R2 design allows this solar panel retention to occur in a balanced and thus safer manner.

Olympic Energy Systems, Inc.

SIZE n x m	# Peak Mounts	# Lift Tensioners	# 10S Rail	# 6S Rail	# 4S Rail
1x1	2	4	0	2	1
1x2	4	8	0	4	2
1x3	6	12	0	6	3
1x4	8	16	0	8	4
1x5	10	20	0	10	5
1x6	12	24	0	12	6
1x7	14	28	0	14	7
1x8	16	32	0	16	8
1x9	18	36	0	18	9
1x10	20	40	0	20	10
2x1	2	4	0	2	2
2x2	4	8	0	4	4
2x3	6	12	0	6	6
2x4	8	16	0	8	8
2x5	10	20	0	10	10
2x6	12	24	0	12	12
2x7	14	28	0	14	14
2x8	16	32	0	16	16
2x9	18	36	0	18	18
2x10	20	40	0	20	20
3x1	2	4	2	0	2
3x2	4	8	4	0	4
3x3	6	12	6	0	6
3x4	8	16	8	0	8
3x5	10	20	10	0	10
3x6	12	24	12	0	12
3x7	14	28	14	0	14
3x8	16	32	16	0	16
3x9	18	36	18	0	18
3x10	20	40	20	0	20
4x1	2	4	2	2	2
4x2	4	8	4	4	4
4x3	6	12	6	6	6
4x4	8	16	8	8	8
4x5	10	20	10	10	10
4x6	12	24	12	12	12
4x7	14	28	14	14	14
4x8	16	32	16	16	16
4x9	18	36	18	18	18
4x10	20	40	20	20	20
5x	Above	Above	4 per Column	0	Above
6x	Above	Above	4 per Column	0	Above

Table – R2 Kit DEFINITION [LANDSCAPE]

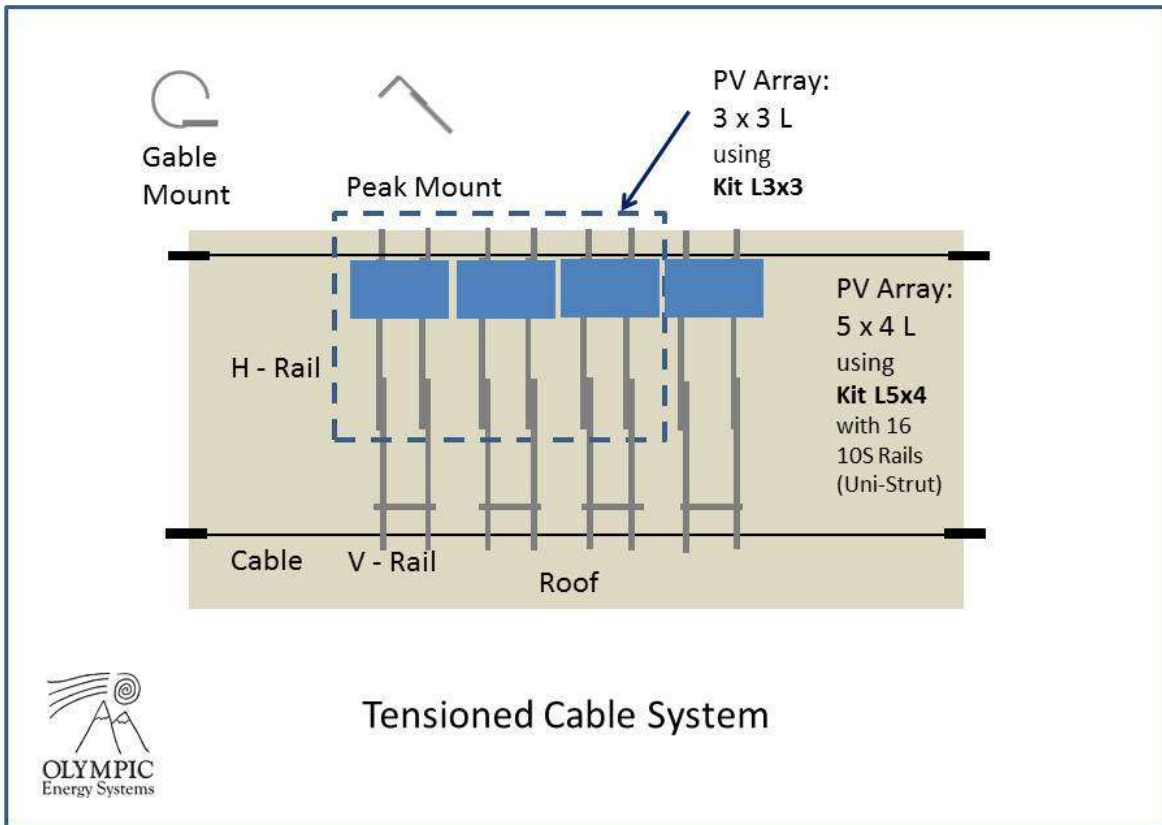


Figure – R2 Component Layout [LANDSCAPE]

The R2 Landscape Kits have fewer rails overall than R2 Portrait Kits and are simpler to lay out and install. The final approach may come down to aesthetics and personal preference.

R1 Landscape Kits have not been described in this manual. R1 Landscape Kits are essentially R1 Portrait Kits with additional horizontal rails. R1 Landscape Kits tend to provide a stronger installation and provide more space between panels and the roof surface due to the extra vertical rails beneath the horizontal rails, perhaps making the installation and wiring easier. The R1 Landscape selection data is forthcoming. Custom mounting kits are always an option, as well. Call for details.

Electrical grounding the solar PV array is straightforward, as all panels encounter metal Uni-Strut rails, which are ready made for various mounting and attaching options. Consult an electrical contractor for more specific methods. Indeed, all PV arrays must be adequately grounded and comply with the NEC.

Solar Panel Make & PV Model #	Power Output Watts (Single String)	String SIZE # Panels	Land-scape n x m n rows	Portrait n x m n rows	ROOF Mounting System Definition Number a = Orientation L or P bb = Roof Pitch ##/12 c = Overhang Y or N ddd = Roof Width, inches TCS-xx-nxmabbc-ddd-PV Model #	KIT PRICE (w/out PV) Retail
Kaneka <i>G-SA060</i>	480	8	2 x 4	1 x 8	TCS-R1-nxmabbc-ddd-G-SA060	\$499
Sanyo <i>HIT Power 200</i>	1200	6	2 x 3	1 x 6	TCS-R1-nxmabbc-ddd-HITPower200	\$499
Solar World <i>SW175</i>	1400	8	4 x 2	2 x 4	TCS-R1-nxmabbc-ddd-SW175	\$499
Sun Power <i>SPR-210-BLK</i>	1680	8	4 x 2	2 x 4	TCS-R1-nxmabbc-ddd-SPR-210	\$499
Trina Solar <i>180-DC01</i>	1440	8	2 x 4	1 x 8	TCS-R1-nxmabbc-ddd-180-DC01	\$499
Others (8) <i>Medium Voc</i>	Varies	10	n x m	n x m	TCS-R1-nxmabbc-ddd-ES-180 etc.	\$699
Others (4) <i>Low Voc</i>	Varies	16	n x m	m x n	TCS-R1-nxmabbc-ddd-ND-130 etc.	\$899

Table - System Definition Number (SDN) Chart

Process Example



SDN = TCS-R1-1x2P12Y-192-KD135SX

KIT Number = TCS-R1-K1S (Special) [Not defined herein]

NOTE: The Kit Number actually equates to a specification of the component parts and quantities required to mount solar panels for a specific (customer) system defined by the SDN. The SDN will allow the required cable lengths, Gable Mounts, and Peak Mounts to be fabricated and provided in kits.

Ground Mount Kits are simpler to specify than roof kits. A single string is mounted on the ground. As solar panels come in varying widths, the different ground mount kits vary mainly in cable length and size of earth anchors. A table is shown for a representative set of available solar PV panels. The ground mount footprint is about 5 by 40 feet. Multiple strings are implemented with multiple mounting kits.

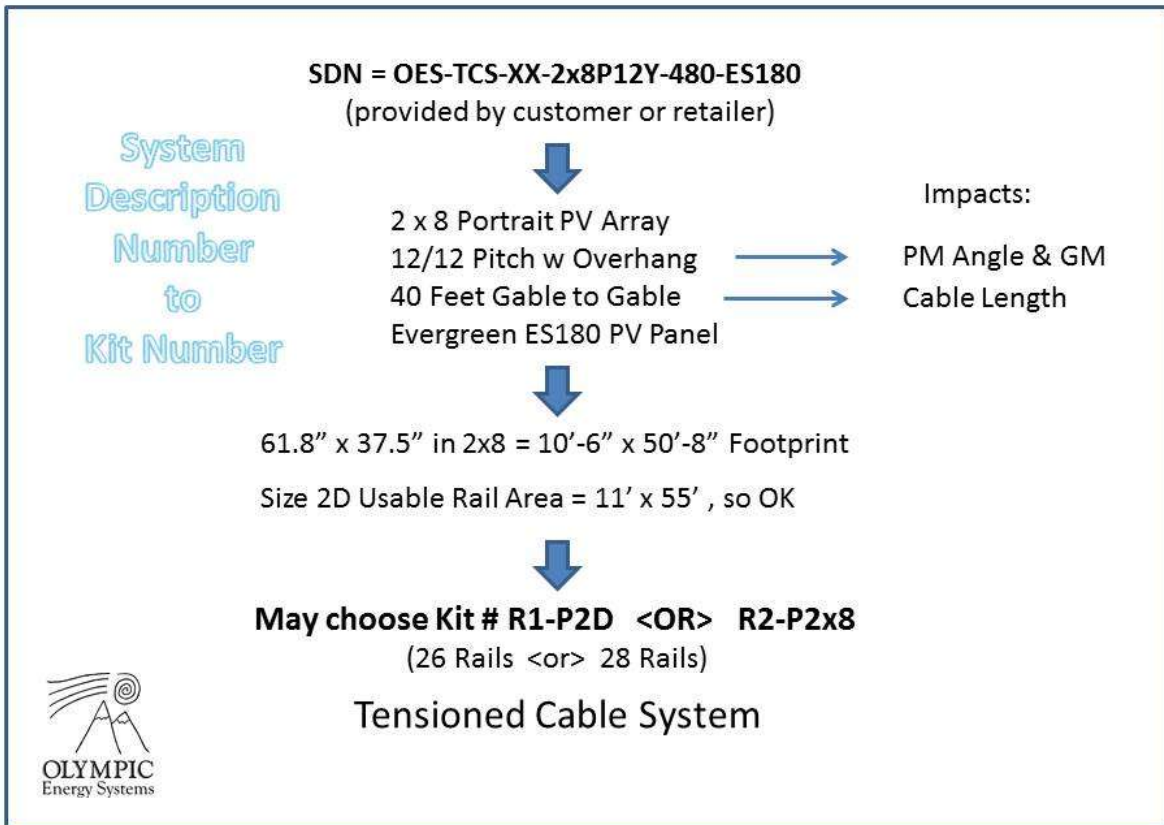


Figure – SDN to Kit Number Mapping

Solar Panel Make & MODEL	String SIZE # Panels	System Voltage VDC	Power Output Watts	GROUND Mounting KIT PART NUMBER	KIT PRICE (w/out PV) Retail
Kaneka <i>G-SA060</i>	8	368	480	TCS-G1-2-14	\$799
Sanyo <i>HIT Power 200</i>	6	414	1200	TCS-G1-2-10	\$799
Solar World <i>SW175</i>	8	352	1400	TCS-G1-2-12	\$799
Sun Power <i>SPR-210-BLK</i>	8	384	1680	TCS-G1-2-12	\$799
Trina Solar <i>180-DC01</i>	8	352	1440	TCS-G1-2-12	\$799
Others (8) <i>Medium Voc</i>	10	352	2100	TCS-G1-2-16	\$999
Others (4) <i>Low Voc</i>	16	352	Varies	TCS-G1-2-18	\$1099

Solar Panel Make & MODEL	String SIZE # Panels	Power Output Watts	PV (String) PRICE Estimated CALL to confirm	KIT PRICE (w/out PV) Retail	TOTAL PV + Mount \$/Watt
Kaneka <i>G-SA060</i>	8	480	\$960	\$799	\$3.66
Sanyo <i>HIT Power 200</i>	6	1200	\$3200	\$799	\$3.33
Solar World <i>SW175</i>	8	1400	\$3380	\$799	\$2.99
Sun Power <i>SPR-210-BLK</i>	8	1680	CALL	\$799	CALL
Trina Solar <i>180-DC01</i>	8	1440	CALL	\$799	CALL
Others (8) <i>Medium Voc</i>	10	2100	CALL	\$999	CALL
Others (4) <i>Low Voc</i>	16	Varies	CALL	\$1099	CALL



OES-TCS-G1-2-12 (Patent Pending) – installs a string of PV for Grid-Tie

Recommendations (Tips, Rules of Thumb, and Lessons Learned)

The roof mount kits install with relative ease, as there are no roof penetrations to map out and there is no balance of PV weight with cable tension as required with the ground mounts. Mounting on the ground has the distinct advantage of not having to work on a sloping surface. With patience, the loading of PV panels and the tensioning of cables with the ground mount units become second nature, as one begins to understand that balancing forces is a matter of small tweaks and of anticipating tensions set up when all panels are in place. The system has adjustability built in, so the key is the final tensioning, not the small tweaks along the way to completion.

System Schematic

TBD

EARLY PROTOTYPES (Historical Only)



Initial Prototyping in July 2009 re Roof (Eave to Eave) – Port Angeles, WA

Prototyping in July 2010 re Roof (Gable to Gable)

Prototyping in December 2010 re Roof (Peak Mount)



Prototyping in September 2010 re Ground (Stanchions) – Findlay, OH

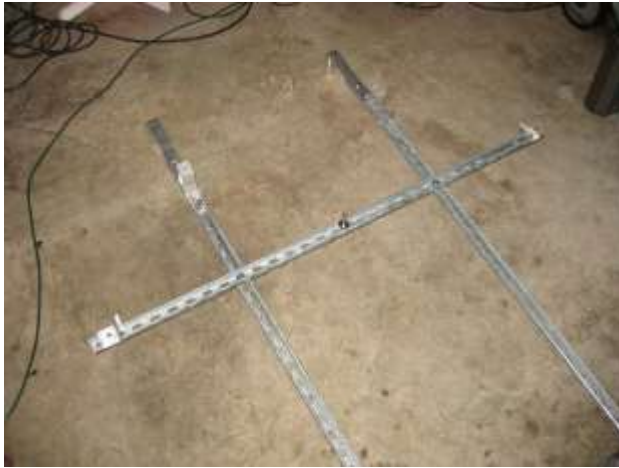
Prototyping in September 2010 re Ground (Single Span)

Prototyping in September 2010 re Ground (Simulated PV)

Pictorial Assembly Sequence



Kits are delivered w/ all hardware except Uni-Strut



Small arrays can be pre-assembled before mounting



This overhang allows an "under" mount pivot joint



Pivot Joint (initial design prior to universal joint)



TCS Gable Mount Pivot Joint for R1 and R2 (New Design)



TCS G1 after 6 months with Simulated PV panels



TCS Gable Mount Pivot Joint attaches either UNDER the gable overhang, OR



Mounts on the surface of the gable trim, at the location of outriggers; sides prevent tipping during installation.



TCS R1 holding real PV panels. [Previous Design]



Small rails can be carried up a ladder and placed



PV Clips hold the PV panel prior to clamping



GM Mount w/ Pull Tensioner (Pad not installed yet)



Initial Stanchion assembly (pre-assembled in kits)



A Cross Brace is added next for front back stability



The cut ends still need soaking coats of preservative



Ground should be tamped before setting pier block



PV Hanger has a series of indents to capture cable



PV Hanger holds PV panel before clamping



One side then the other (simulated PV panels)



Assembly proceeds inward (starts w/ least sag)



Representative mounting w/ simulated PV panels



Cross Tie Turnbuckle (initial installation)



Turnbuckles allow capturing cross tie length



Cross Straps (final installation) held w/ pop rivets

Design Science Plan for Tensioned Cable Systems

TBD

Certifications and Approvals

No certifications or approvals exist at this time, though they are anticipated in certain jurisdictions, such as California. Local codes and regulations may apply. Some cities require a mechanical inspection of the roof mounting system. Most counties do not require building permits for roof mount systems if overall weight is under 5 pounds per square foot.

Warranty Information

A one year warranty on mounting kits for workmanship and performance is provided, with part replacement upon verification of any problem. Metallurgical issues are anticipated, believed to be only aesthetic in nature. All attempts have been made to secure quality metal and pre-fabricated parts.

Appendix

TBD