

PRELIMINARY

# Tensioned Cable System (TCS)

## Mounting Kits

### GUIDE

For Selecting  
Solar Panel Mounting Kits

(TCS-R1-###)

(TCS-R2-##x#)

(TCS-G1-#-##)

REV Draft 2/27/11

Technical Support: (360) 301-5133

[www.olympicenergysystems.com](http://www.olympicenergysystems.com)



Roof Mount Kit  
(Example)

### **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)

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 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, 12 feet nominal per Span



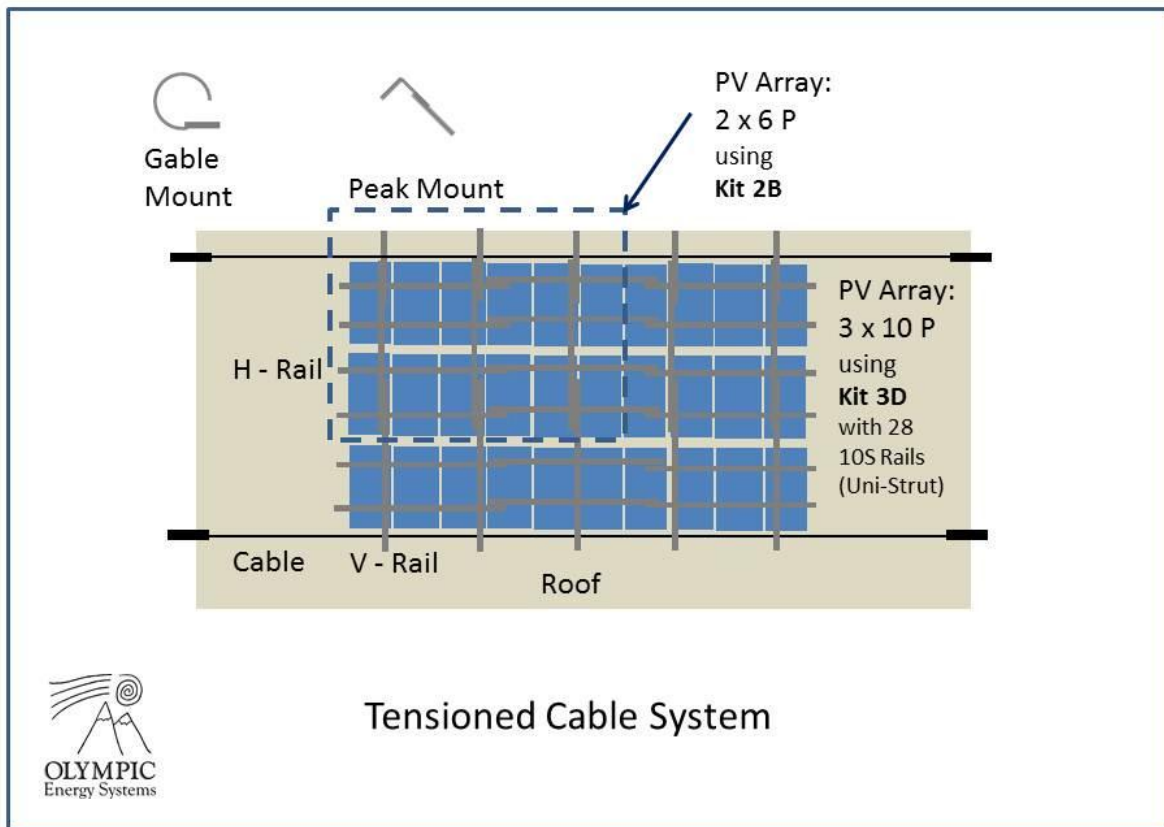


Figure – R1 Component Layout [PORTRAIT]

### 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]**

<b>Model No.</b>	<b>1A</b>	<b>1B</b>	<b>1C</b>	<b>1D</b>	<b>1E</b>	<b>2A</b>	<b>2B</b>	<b>2C</b>	<b>2D</b>	<b>2E</b>	<b>3A</b>	<b>3B</b>	<b>3C</b>	<b>3D</b>	<b>3E</b>	<b>Power Kit 3E</b>
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**

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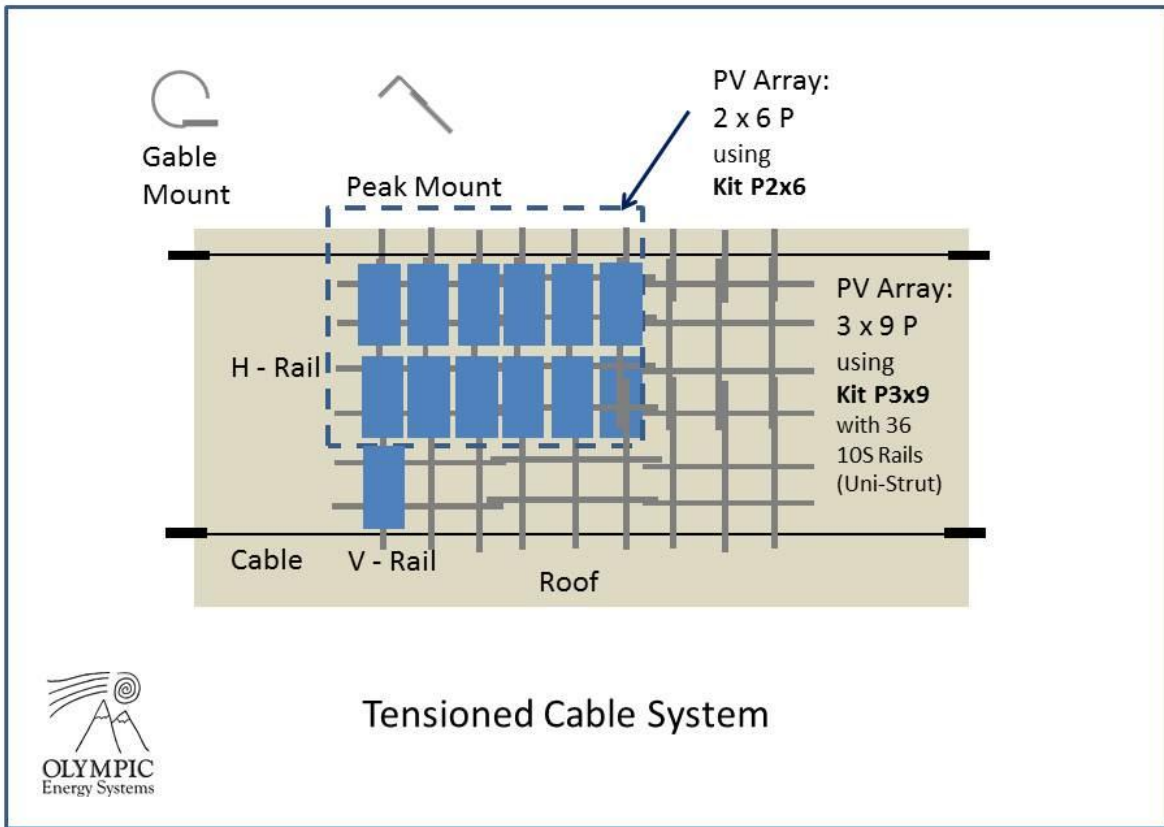
SIZE n x m	# Peak Mounts	# Lift Tensioners	Quantity 10S Rail	Quantity 6S Rail
1x3	3	6	2	3
1x4	4	8	4	4
1x5	5	10	4	5
1x6	6	12	4	6
1x7	7	14	6	7
1x8	8	16	6	8
1x9*	9	18	6	9
1x10	10	20	8	10
1x11	11	22	8	11
1x12*	12	24	8	12
1x13	13	26	10	13
1x14	14	28	10	14
1x15*	15	30	10	15
2x3	3	6	7(10)	3(0)
2x4	4	8	12(16)	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.

<b>SIZE n x m</b>	<b># Peak Mounts</b>	<b># Lift Tensioners</b>	<b># 10S Rail</b>	<b># 6S Rail</b>	<b># 4S Rail</b>
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]**

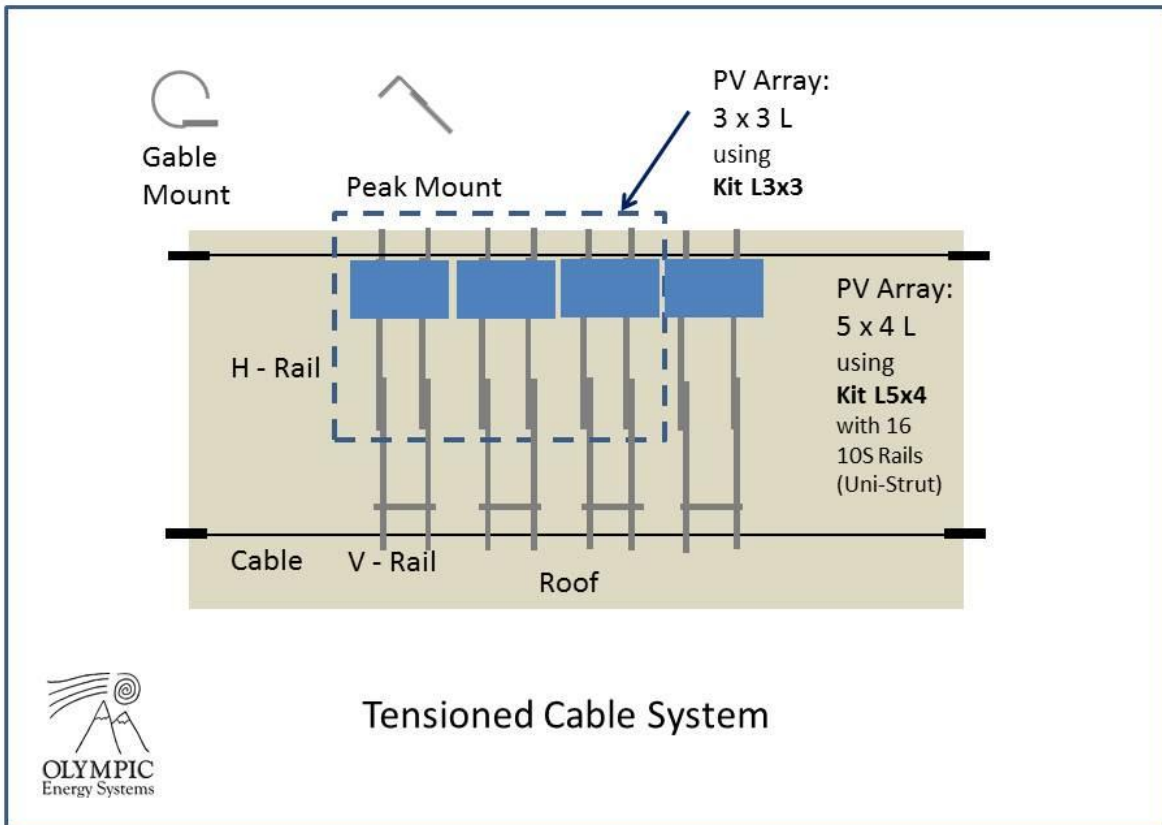


Figure – R2 Component Layout [LANDSCAPE]

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.

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

**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.

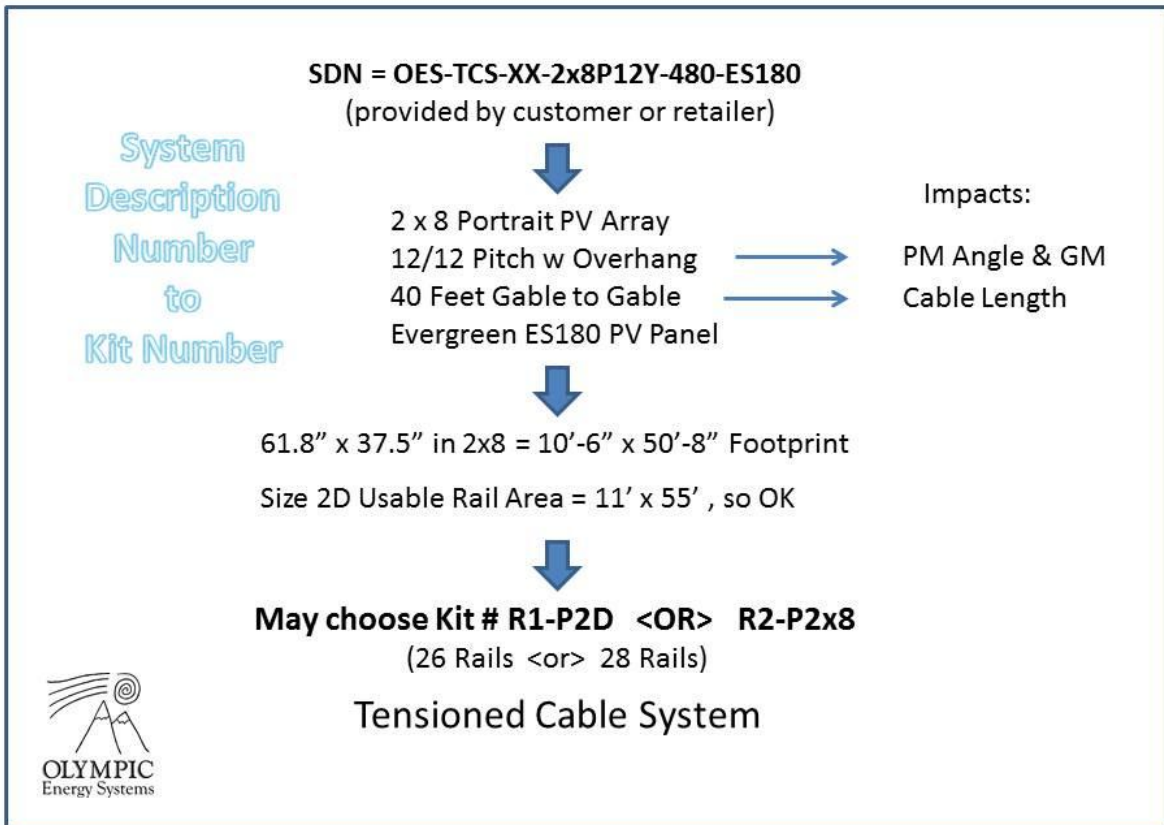


Figure – SDN to Kit Number Mapping

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

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



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

## **TCSPMS – Tensioned Cable Solar Panel Mounting System**

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

TCS Specification REV DRAFT – Preliminary  
February 22, 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)

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)  
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.