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(54) **SELF-BALLASTING SOLAR ARRAY MOUNT**

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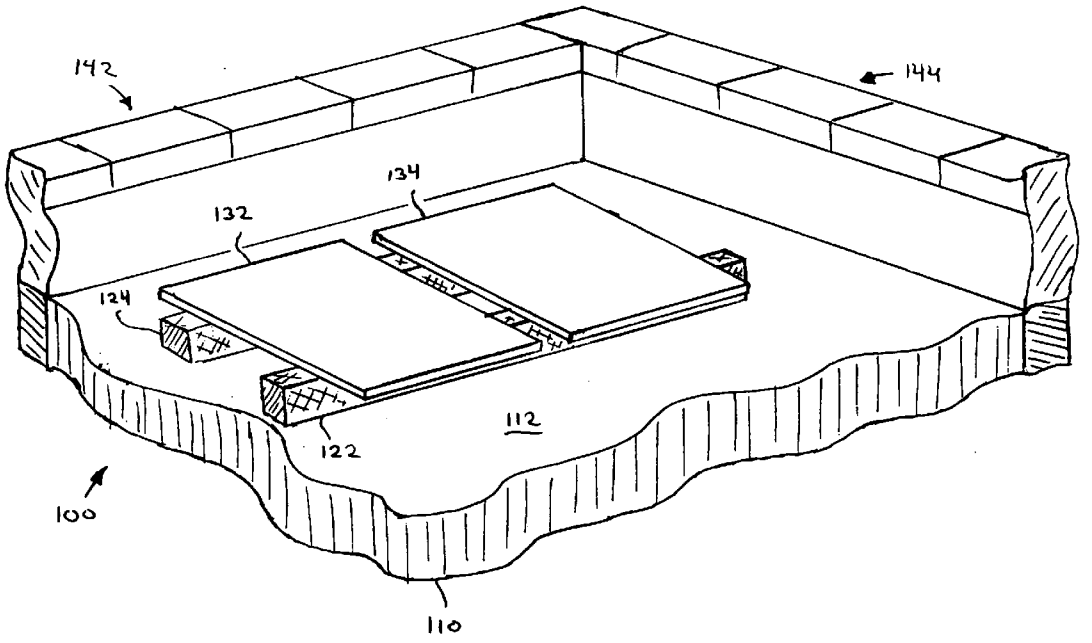
(57) **ABSTRACT**

A solar panel installation includes a number of solar panels supported by two or more beams that are arranged parallel to each other on the surface of a roof. Each panel is arranged across and supported by multiple ones of the beams. The combined weight of the beams at least equals the combined weight of the panels, which permits the use of panels that are lighter and easier to handle than ones whose weight forms the bulk of the ballast. For example, the beams advantageously can have about twice as much combined weight as the combined weight of the panels. Various aspects and variations are also disclosed.



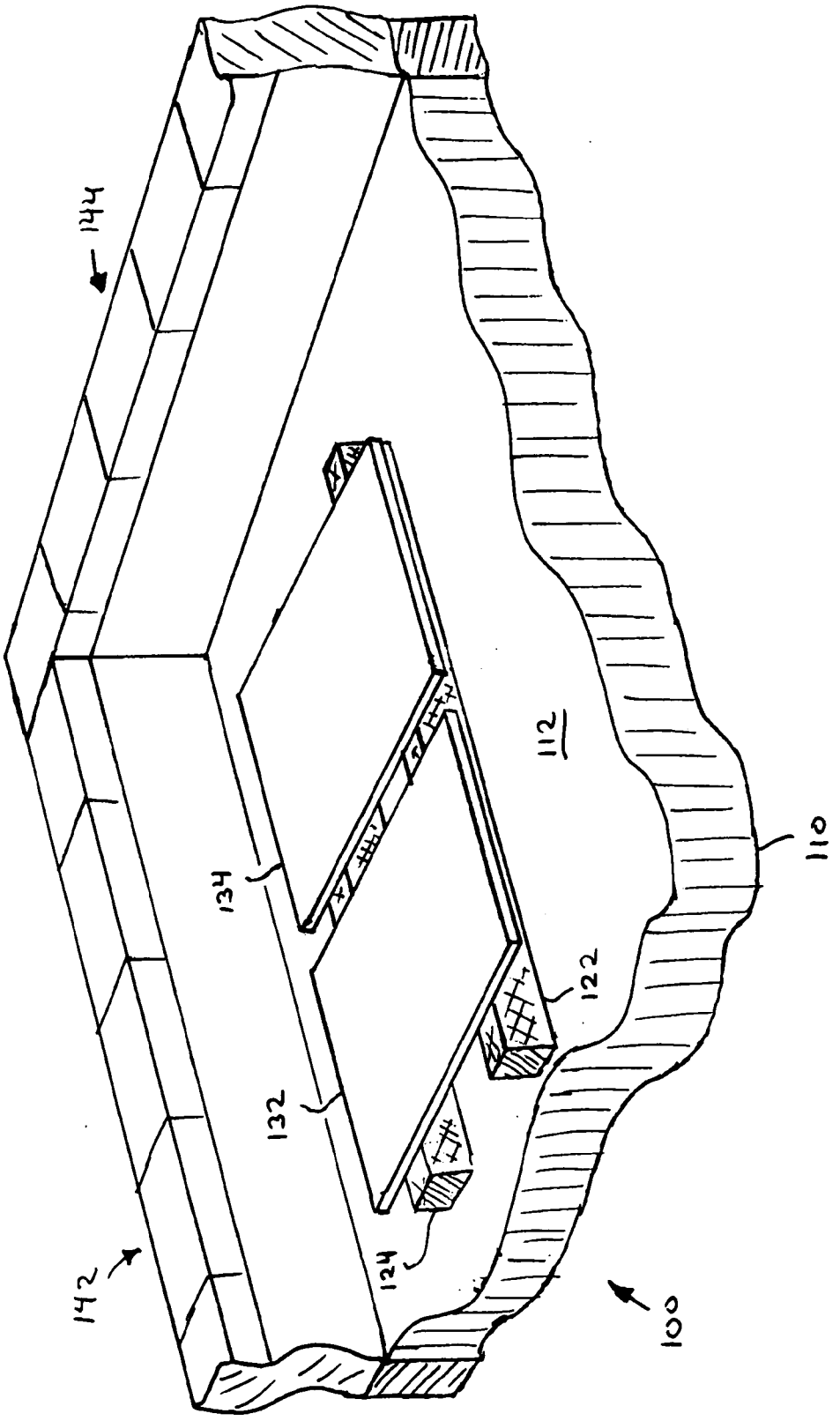
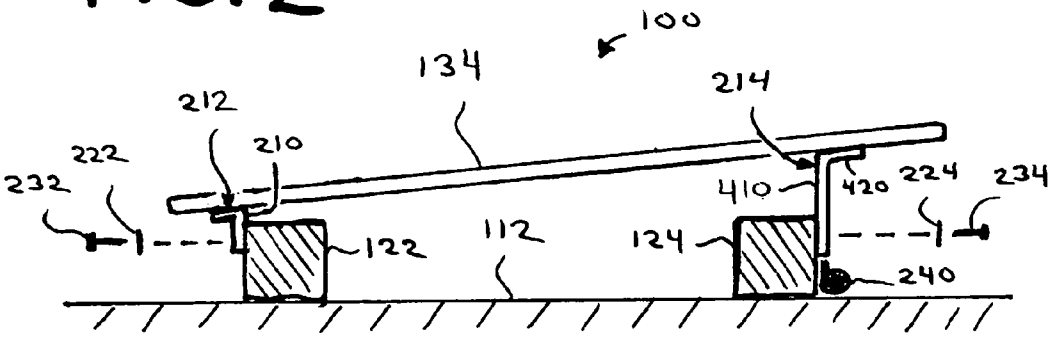


FIG. 1

FIG. 2



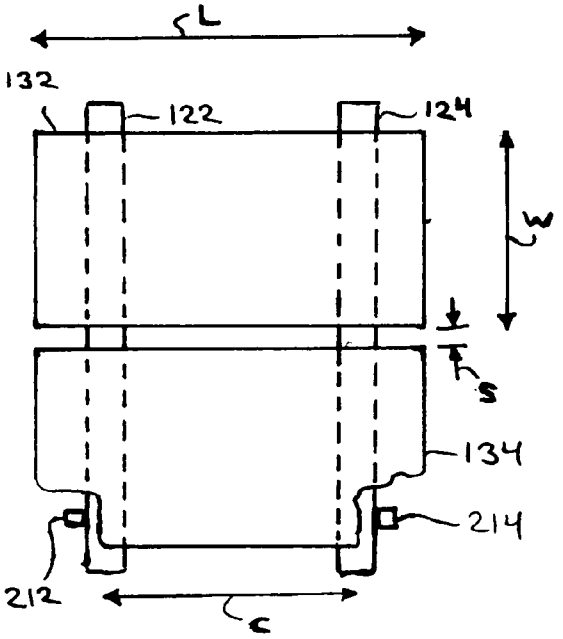


FIG. 3

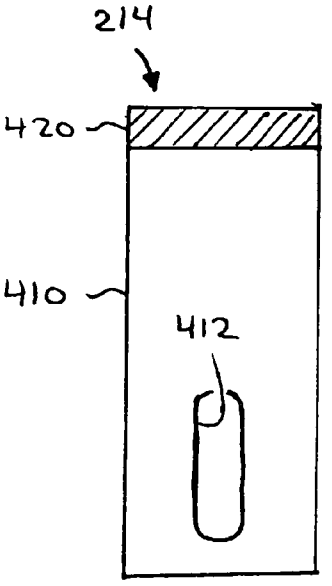


FIG. 4

SELF-BALLASTING SOLAR ARRAY MOUNT

FIELD OF THE INVENTION

[0001] The invention involves the field of roof-mounted solar panels for buildings, useful for converting sunlight into electrical or thermal energy.

BACKGROUND OF THE INVENTION

[0002] Flat building roofs are often highly desirable locations for mounting solar panels, i.e., planar devices for collecting solar energy and converting it to electrical or thermal form. Such energy conversion in solar panels can be accomplished using a variety of systems, including photovoltaic cells, liquid-heating systems, or other systems (the energy conversion method employed by the panels is not material to this invention). Flat rooftops often have large amounts of unused area with unobstructed exposure to sunlight. But it is generally considered undesirable to mount solar panels on flat roofs with any kind of hardware that requires penetration of the roofing material, e.g., screws or bolts. Accordingly, for example, U.S. Pat. No. 5,746,839 to Dinwoodie discusses a light weight, self-ballasting solar cell roofing assembly, purportedly eliminating the need for roof membrane penetrations for hold-down.

[0003] In the roofing assembly of the Dinwoodie patent, a photovoltaic module performs the multiple functions normally provided by a roofing paver, including ballast. However, photovoltaic modules that are heavy enough to provide the ballast needed for mounting without penetrating the roofing are difficult to transport onto rooftops for installation.

[0004] Accordingly, it would be desirable to have a way of mounting solar panels on rooftops without penetrating the roofing material with mounting hardware and without increasing the weight of the solar panels for ballast purposes to a point where they are unwieldy and difficult to install.

SUMMARY OF THE INVENTION

[0005] A solar panel installation according to various aspects of the invention includes a number of solar panels supported by two or more beams that are arranged parallel to each other on the surface of a roof. Each panel is arranged across and supported by multiple beams. The combined weight of the beams at least equals the combined weight of the panels, which permits the use of panels that are lighter and easier to handle than ones whose weight forms the bulk of the ballast. For example, the beams advantageously can have about twice as much combined weight as the combined weight of the panels.

[0006] The system can include a number of short angle brackets connected to one of the beams and to the panels, and a number of longer angle brackets connected to another one of the beams and to the panels. The short angle brackets connect near one edge of each panel, and the longer ones connect near an opposite edge. Preferably, a pair of each type of bracket connects to each panel. The longer angle brackets support the panels at a substantially greater height above the beams than the short angle brackets. Thus, in embodiments with such angle brackets, the panels are tilted at a desired angle from horizontal. As a result, rainwater flows off the panels more easily and increased solar energy density falls on the panel surfaces in non-equatorial latitudes.

[0007] The beams can consist substantially of high-density polyethylene, a relatively inexpensive and durable substance. Advantageously, the primary component of the beams can be reclaimed post-consumer high-density polyethylene, which is appealing from an environmental standpoint.

[0008] The above summary does not include an exhaustive list of all aspects of the present invention. Indeed, the inventor contemplates that the invention includes all systems and methods that can be practiced from all suitable combinations of the various aspects summarized above, as well as those disclosed in the detailed description below and particularly pointed out in the claims. Such combinations have particular advantages not specifically recited in the above summary.

BRIEF DESCRIPTION OF THE DRAWINGS

[0009] **FIG. 1** is a partial perspective view of a solar panel installation according to various aspects of the invention.

[0010] **FIG. 2** is a side view of the system of **FIG. 1**.

[0011] **FIG. 3** is a top view of the system of **FIG. 1**.

[0012] **FIG. 4** is a side view of an angle bracket employed in the system of **FIG. 1**.

DESCRIPTION OF PREFERRED EXEMPLARY EMBODIMENTS

[0013] A self-ballasting solar panel mounting system according to various aspects of the present invention advantageously provides a stable base for solar panels on a rooftop while avoiding the need to penetrate the roofing material of the rooftop with mounting hardware such as bolts or screws. **FIG. 1** illustrates an exemplary system **100** in which two solar panels **132**, **134** are mounted atop beams **122**, **124** arranged parallel to each other on a generally flat roof surface **112**. Rooftop **112** may sit atop a residential, commercial, industrial, or public building of any sort.

[0014] Beams **122**, **124** rest on rooftop **112** without the need for any mechanical fasteners to penetrate the roofing material of rooftop **112** or adhesives to bond to it. Instead, beams **122**, **124** are kept in contact with rooftop **112** by their ballast weight and a lesser amount of ballast weight provided by solar panels **132**, **134**.

[0015] To develop more electrical power than the quantity produced by panels **132**, **134**, additional beams (not shown) can be lined up end-to-end with beams **122**, **124**. In an alternative embodiment not shown, a single pair of beams can extend to a total length several times greater than that of beams **122**, **124** and support more panels.

[0016] One advantageous configuration (not shown) includes multiple (e.g., a total of five) collinear pairs of beams, like beams **122**, **124**, that are lined up to support a row of several (e.g., ten) solar panels, like panels **132**, **134**. To further increase the amount of electrical power generated, such rows of solar panels can be arranged parallel to each other, e.g., five or six rows forming an array of 50 or 60 solar panels that generates a total peak power output of about 9-11 kW. Solar panels of higher efficiency or greater surface area can generate more power per panel, e.g., 190 W, for a larger total output.

[0017] Exemplary beams **122**, **124** are each 1.7 meters long and have cross-sectional dimensions of 15 cm by 15 cm. Their length is just sufficient to support a row of two solar panels that each measure about 1.6 meters in length by 0.8 meters in width, allowing about 5 cm of separation between the panels. For clarity, **FIG. 1** illustrates beams **122**, **124** as extending somewhat beyond the edges of panels **132**, **134**. To conserve rooftop space, however, the ends of beams **122**, **124** are preferably nearly flush with the edges of panels **132**, **134**.

[0018] Each one of beams **122**, **124** weighs about 30 kg, which is light enough for a pair of workers to carry easily. Solar panels **132**, **134** each weigh about 17 kg. Thus, in combination, the two beams outweigh the panels mounted on them by about a two-to-one ratio and provide the bulk of the ballast needed to keep system **100** in contact with rooftop **112**, even during a full range of ordinarily anticipated weather conditions (including expected peak wind speeds).

[0019] For clarity, **FIG. 1** illustrates optional parapets **142**, **144** that extend above rooftop **112**. However, the ballast provided primarily by beams **122**, **124** keeps system **100** securely mounted on rooftop **112** even without any wind shielding that parapets **142**, **144** may offer.

[0020] Beams of a solar panel mounting system of the invention can be fabricated from any suitably dense material, such as high-density polyethylene. A particularly advantageous type of high-density polyethylene for fabrication of the beams is available as compressed structural units of reclaimed post-consumer waste. For example, sections of plastic lumber such as that marketed by Polywood, Inc. of Edison, N.J. can be employed. If desired, e.g., to comply with terms of a warranty on the roof surface, pieces of thin roofing membrane can be placed between the beams and the roof surface.

[0021] As may be better understood with reference to the side view of **FIG. 2**, the solar panels of system **100** are mounted above beams **122**, **124** with some tilt from horizontal to rooftop **112**. As illustrated, solar panel **134** has a tilt of about 5 degrees from horizontal, which significantly improves the amount of solar energy per unit area falling on panel **134** under most conditions in non-equatorial latitudes. The modest amount of tilt also avoids pooling of rainwater. It is limited to avoid presenting too much area from a horizontal perspective and consequent wind loading, and to limit lift that would develop from wind passing over and under the panel if tilted more.

[0022] Angle brackets **212**, **214** mount solar panel **134** to beams **122**, **124**, respectively, with different heights above each beam to achieve the desired tilt angle. For the 5 degree tilt illustrated in **FIG. 2**, bracket **214** has a vertical portion **410** that is 17.8 cm in length. The corresponding vertical portion **210** of bracket **212** is only 7.6 cm in length. Thus, in exemplary system **100**, the lower edge of solar panel **134** is 21.3 cm above rooftop **112** and the higher side is 34.9 cm above rooftop **112**. Such tilts may also be varied in situations where rooftop **112** is not entirely flat, as needed to meet the demands of the system.

[0023] Except for the difference in dimensions, angle brackets **212**, **214** have the same overall structure. Both brackets can be made of any suitable material, e.g., aluminum or hot dip galvanized steel. From two different angles of view, **FIG. 2** and **FIG. 4** illustrate vertical portion **410** and horizontal portion **420** of bracket **214**. Vertical portion **410** includes an elongated hole **412** for mounting bracket **214** to beam **124** at a desired vertical position with reference to a mounting screw **234** and washer **224** (**FIG. 2**). When plastic lumber is employed for fabrication of beam **124**, screw **234** is preferably stainless steel. A similar screw **232** and washer **222** are employed for attachment of bracket **212** to beam **122**. Removal of screws from plastic lumber can be difficult, so any needed disassembly is best done by unbolting the solar panel from the bracket, and, if necessary, cutting the heads off the screws that attach the brackets to the beams.

[0024] Beams **122**, **124** advantageously can support structures other than solar panels **132**, **134**. For example, **FIG. 2** illustrates a cross-section **240** of a conduit containing wiring that conveys electrical current from panels **132**, **134** to other structure not shown, e.g., to a phase-synchronous inverter that is connected back to an electrical power grid supplying the building of which rooftop **112** is a part. As an alternative to conduit, small junction boxes (not shown) can be mounted on the beams next to some of the brackets that support the solar panels, as needed to provide electrical connections for the panels.

[0025] Installation of system **100** on rooftop **112** can be performed as follows. First, a worker lays out the beams in the proper positions. Then, he or she loosely bolts four brackets to the underside of the frame of a solar panel. Then the solar panel is placed over the beams with supports for the top and bottom edge of the solar panel to hold them at the proper heights. Then the worker drives screws horizontally through the brackets into the beams. Then the bolts connecting the brackets to the solar panel frame are tightened. The process of bolting the brackets to the panels and to the beams is repeated for any additional panels to be mounted on the same beams.

[0026] Preferred dimensions of system **100** may be better understood with reference to **FIG. 3** and TABLE I below.

TABLE I

Structural Feature	Preferred Dimension
Panel length (L)	157.5 cm
Panel width (W)	82.6 cm
Separation (S) between panels	3.8 cm
Beam center spacing (C)	109 cm

[0027] Other dimensions can be employed to accommodate the desired number of panels and beams, the dimensions of the panels to be supported, and the aesthetic goals for the installation.

PUBLIC NOTICE REGARDING THE SCOPE OF THE INVENTION AND CLAIMS

[0028] No one embodiment disclosed herein is essential to the practice of another unless indicated as such. Indeed, the invention, as supported by the disclosure above and in the originally filed claims, includes all systems and methods that can be practiced from all suitable combinations of the various aspects disclosed, and all suitable combinations of the exemplary elements listed. Such combinations have particular advantages, including advantages not specifically recited herein.

[0029] Alterations and permutations of the preferred embodiments and methods will become apparent to those skilled in the art upon a reading of the specification and a study of the drawings. For example, three parallel beams can be employed instead of two in situations where lighter beams are desired for easier carrying or the solar panels are particularly wide. It can then be useful to use three beams instead of two. Such a configuration can maintain the desired ballast distribution, where the combined beam weight is at least as great as the combined weight of the panels they support.

[0030] Accordingly, none of the disclosure of the preferred embodiments and methods defines or constrains the invention. Rather, the issued claims variously define the invention. Each variation of the invention is limited only by the recited limitations of its respective claim, and equivalents thereof, without limitation by other terms not present in the claim. For example, claims that do not call for any exact number of elements in a plurality, or any particular dimensions of such elements, are not limited to the specific dimensions and dual-beam configuration of exemplary system **100**.

[0031] In addition, aspects of the invention are particularly pointed out below using terminology that the inventor regards as having its broadest reasonable interpretation; the more specific interpretations of 35 U.S.C. § 112(6) are only intended in those instances where the terms "means" or "steps" are actually recited. The words "comprising,""including," and "having" are intended as open-ended terminology, with the same meaning as if the phrase "at least" were appended after each instance thereof. A clause using the term "whereby" merely states the result of the limitations in any claim in which it may appear and does not set forth an additional limitation therein. The conjunction "or" between alternative elements means "and/or," and thus does not imply that the elements are mutually exclusive unless context or a specific statement indicates otherwise.

What is claimed is:

1. An apparatus comprising:

(a) a plurality of beams arranged parallel to each other on the surface of a roof; and

(b) a plurality of solar panels, with each panel being arranged across and supported by multiple ones of the beams;

(c) wherein the combined weight of the beams at least equals the combined weight of the panels.

2. The apparatus of claim 1 wherein the beams have about twice as much combined weight as the combined weight of the panels.

3. The apparatus of claim 2 wherein the beams consist substantially of high-density polyethylene.

4. The apparatus of claim 3 wherein the beams consist primarily of reclaimed post-consumer high-density polyethylene.

5. The apparatus of claim 2 wherein the plurality of beams consists of two beams.

6. The apparatus of claim 5 wherein both beams are of like dimensions.

7. The apparatus of claim 6 further comprising:

(a) a plurality of first angle brackets connected to a first one of the beams and to the panels near a first edge of each panel; and

(b) a plurality of second angle brackets connected to the second one of the beams and to the panels near a second edge of each panel opposite the panel's first edge;

(c) wherein, for each panel, the first and second angle brackets support the panel at substantially different heights, such that the panel is significantly tilted from horizontal with respect to the surface of the roof.

8. The apparatus of claim 7 wherein a pair of first angle brackets and a pair of second angle brackets connects to each panel.

9. The apparatus of claim 7 wherein the second height is several times greater than the first height.

10. The apparatus of claim 9 wherein both beams are fabricated primarily of reclaimed post-consumer high-density polyethylene.

11. A method for mounting solar panels on a rooftop, comprising:

(a) placing on a rooftop a plurality of beam sections, parallel to each other; and

(b) mounting a plurality of solar panels on the beam sections, with each panel being arranged across and supported by multiple ones of the beam sections;

(c) wherein the combined weight of the beam sections at least equals the combined weight of the panels.

12. The method of claim 11 wherein the beam sections placed on the rooftop have about twice as much combined weight as the combined weight of the panels mounted thereon.

13. The method of claim 12 wherein the beam sections consist substantially of high-density polyethylene.

14. The method of claim 13 wherein the beams consist primarily of reclaimed post-consumer high-density polyethylene.

15. The method of claim 12 wherein placing the beam sections on the rooftop comprises placing two beams on the rooftop parallel to each other.

16. The method of claim 15 wherein both of the beam sections are of like dimensions.

17. The method of claim 14 further comprising, for each panel:

(a) connecting one or more first angle brackets to a first one of the beam sections;

(b) connecting one or more second angle brackets to the second one of the beam sections; and

(c) mounting the panel on the beam sections by connecting it to the first angle brackets near one of its edges and to the second angle brackets near an opposite one of its edges;

(d) wherein connecting the panel to the first and second angle brackets comprises mounting the panel such that its opposing edges connected to the angle brackets are at substantially different heights, such that the panel is significantly tilted from horizontal with respect to the surface of the roof.

18. The method of claim 17 wherein part (c) is performed after parts (a) and (b).

19. The method of claim 17 wherein parts (a) and (b) comprise connecting a pair of first angle brackets and a pair of second angle brackets to the panel.

20. A solar panel installation on a rooftop comprising:

(a) a plurality of solar panels; and

(b) mounting means, having at least as much combined weight as the combined weight of the solar panels, for supporting the solar panels on the rooftop under gale-force wind loading without substantial movement or reliance on penetrating mechanical attachment to the rooftop.

21. The solar panel installation of claim 20 wherein the solar panels are arranged in separate rows on the rooftop, supported by separate arrangements of the mounting means.

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