SOLAR COLLECTOR SUPPORT SYSTEM FOR EFFICIENT STORAGE, TRANSPORT, AND DEPLOYMENT OF AN EXPANDABLE ARRAY OF ROTATABLE SOLAR COLLECTORS

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Abstract
Compact solar collector arrays with multiple axis adjustability for use with mobile structures, such as trailers, RVs, etc., and temporary support structures and associated methods of use are disclosed that provide significant power generation capacity per roof area, easy deployment, optimum orientation regardless of underlying vehicle or structure orientation, and protection for solar collector arrays during transport. Some embodiments include a plurality of solar collector mounts coupled to a support surface, the plurality of solar collector mounts being capable of changing relative spatial arrangement of each solar collector with respect to at least a neighboring solar collector.
Lifting Actuator 642

Tilting Actuator 644

Rotating Actuator 646

Sliding Actuator 656

Sliding Cover Actuator 662

Sensor 648

Controller 640

Fig. 21
SOLAR COLLECTOR SUPPORT SYSTEM
FOR EFFICIENT STORAGE, TRANSPORT, AND DEPLOYMENT OF AN EXPANDABLE ARRAY OF ROTATABLE SOLAR
COLLECTORS

RELATED APPLICATIONS
[0001] This application claims priority to U.S. provisional patent application no. 61/271,925, entitled Sustainable, Mobile, Expandable Structure, filed Jul. 28, 2009, which is incorporated herein by reference in its entirety.

FIELD
[0002] This application relates generally to solar collectors, and particularly to solar collector arrays.

BACKGROUND
[0003] Solar power is becoming increasingly desirable and necessary as other fuel sources become harder to find and more expensive. Solar power provides the advantage that the energy source (the Sun) is freely available throughout the planet, requiring only solar collectors to harvest the power. Solar collectors are getting thinner, lighter, and more efficient as time goes on, making them more viable for more applications.

[0004] However, solar collector applications have been limited for vehicles and for low-surface area structures because of the relatively low power output per area and the necessity of heavy batteries for utilizing solar power at night or when the Sun is otherwise obstructed. Because of the required surface area of solar collectors to provide more than a trivial amount of power, solar collectors have been generally impractical for vehicles such as cars, trucks, campers, RV’s, trailers, etc. and other small structures such as mobile homes, sheds, etc.

[0005] Additionally, the lack of surface area for placing solar collectors can limit the desirability and practicability of using solar collectors on vehicles and small structures, particularly temporarily situated structures such as trailer homes, RV’s, frame tents, travel trailers, work trailers, etc. The lack of surface area is compounded by the lack of positioning options for traditional solar collectors, requiring that the vehicle or temporarily situated structures be placed in a certain orientation to assure power generation by solar collectors.

SUMMARY
[0006] Compact solar collector arrays with multiple axis adjustability for use with mobile structures, such as trailers, RV’s, etc., and temporary support structures and associated methods of use are disclosed that provide significant power generation capacity per roof area, easy deployment, optimum orientation regardless of underlying vehicle or structure orientation, and protection for solar collector arrays during transport. Some embodiments include a plurality of solar collector mounts coupled to a support surface, the plurality of solar collector mounts being capable of changing relative spatial arrangement of each solar collector with respect to at least a neighboring solar collector.

[0007] Each solar collector mount can include: a collector support, the collector support being capable of securing and supporting a solar collector; a rotating mechanism, the rotating mechanism being attached to the collector support, the rotating mechanism providing rotation of the collector support and the solar collector; and a sliding mechanism being attached to the rotating mechanism, the sliding mechanism being supported by the support surface, the sliding mechanism being capable of moving the collector support with respect to the supporting surface.

[0008] The solar collector support system can also include a controller cooperative with the plurality of solar collector mounts, wherein the controller is capable of changing the relative spatial arrangement of the collector supports so that each collector support is capable of unobstructed rotation. In some embodiments, each solar collector mount can further include a tilt mechanism cooperative with at least one of the tray, the rotator, and the translator, and wherein the tilt mechanism can tilt each solar collector.

[0009] Movement of the collector support with respect to the supporting surface can include movement parallel to a front edge of the supporting surface, movement parallel to a side edge of the supporting surface, movement perpendicular to the supporting surface, or any combination of these movements. In some embodiments, the sliding mechanism can include at least one rail coupled to the support surface, the at least one rail having a slot extending along the length of the at least one rail, and a sliding frame engaged in the slot and configured to slide along the length of the rail.

[0010] In certain embodiments, the plurality of solar collector mounts can be movable between a consolidated configuration and a deployed configuration. Retractable panels for covering the plurality of solar collector mounts can be used when in the consolidated configuration. The retractable panels can protect the solar collector mounts from road debris and theft.

[0011] In some embodiments, the plurality of solar collector mounts can positionable for maximum solar energy exposure when in the deployed configuration regardless of the orientation of the support surface. The support surface can be a roof of a mobile structure.

[0012] Methods of using a solar array can include providing a plurality of solar collectors in a consolidated position, the plurality of solar collectors operably connected to form a solar collector array, the plurality of solar collectors being coupled to a support surface; spatially separating the plurality of solar collectors, so as to permit unobstructed rotation of each solar collector; and rotating the plurality of solar collectors to increase solar power generation of the solar panel array. The spatially separating can include moving at least one of the plurality of solar collectors with respect to the supporting surface parallel to a front edge of the supporting surface, movement parallel to a side edge of the supporting surface, movement perpendicular to the supporting surface, or any combination of these movements.

[0013] Some methods can include uncovering the plurality of solar collectors prior to the spatially separating. Similarly, some methods can also include returning the plurality of solar collectors to the consolidated position.

BRIEF DESCRIPTION OF THE DRAWINGS
[0014] The following description can be better understood in light of Figures, in which:
[0015] FIG. 1A is a perspective drawing of an exemplary solar collector with a multiple axis adjustable solar collector mount for use in a solar collector array;
[0016] FIG. 1B is a sectional drawing along section B-B of FIG. 1A;
FIG. 2 is an exploded view of the solar collector with multiple axis adjustable solar collector mount in FIG. 1A;

FIGS. 3-7A are perspective drawings of an exemplary solar collector array being deployed through movement of multiple axis solar collector mounts;

FIGS. 8-11 are perspective drawings of an exemplary solar collector array being deployed through movement of multiple axis solar collector mounts;

FIGS. 12-15 are perspective drawings of an exemplary solar collector array being deployed through movement of multiple axis solar collector mounts;

FIGS. 16-19 are perspective drawings of an exemplary solar collector array being deployed through movement of multiple axis solar collector mounts;

FIG. 20 is a perspective drawing of an exemplary solar collector array deployed on a structure;

FIG. 21 illustrates a schematic diagram of a control system for an exemplary solar collector array.

Together with the following description, the Figures demonstrate and explain the principles of deployable solar collector array support structures for vehicles and associated methods of use. In the Figures, the size, number and configuration of components may be exaggerated for clarity. The same reference numerals in different Figures represent the same component.

DETAILED DESCRIPTION

The following description supplies specific details in order to provide a thorough understanding. Nevertheless, the skilled artisan would understand that embodiments of compact solar collector arrays with multiple axis adjustable solar collector mounts and associated methods of using them can be implemented and used without employing these specific details. Indeed, exemplary embodiments and associated methods can be placed into practice by modifying the illustrated units and associated methods and can be used in conjunction with any other devices and techniques conventionally used in the industry. For example, while the description below generally focuses on embodiments of deployable solar collector arrays for trailers, similar support structures can be used with motorhomes, travel trailers, campers, mobile homes, boats, or other applications where it would be advantageous to have a deployable solar collector array with multi axis adjustable solar collector mounts.

FIGS. 1A-2 illustrate an embodiment of solar collector 110 with multi axis solar collector mount 115 attached to rails 122. Solar collector 110 can be any solar collector or collection of solar cells. Solar collector mount 115 can include collector base 140 and rail base 150. Solar collector 110 can be connected to collector base 140 through tilting mechanism 144 to allow solar collector 110 to tilt with respect to collector base 140. Collector base 140 can include rotating mechanism 146 to rotate collector base and thereby solar collector 110. Collector base 140 can be connected to rail base 150 through lifting mechanism 142 to extend collector base 140 away from rail base 150 and rails 122.

All adjustment mechanisms, such as tilting mechanism 144, lifting mechanism 142 rotating mechanism 146, etc., can be actuated using any practical method. For example, actuators, such as servo motors, stepper motors, linear actuators, solenoids, etc., can be used, depending on the application and design preference can be implemented readily. Similarly, the adjustment mechanisms may be positioned by hand.

Accounting from the plane formed by the bottom of rail base 150 as the x-y plane, the various adjustment mechanisms of collector mount 115 attached to rails 122 can together allow for x or y translation, z translation, z rotation, and an x-y rotation (depending on the z rotation position) of solar collector 110 attached to collector mount 115.

Tilting mechanism 144 can be a scissor mechanism. Solar collector 110 can be hingedly attached to collector base 140 on one side and with the scissor mechanism of tilting mechanism 144 on the other side. When tilting mechanism 144 is activated, an end of solar collector 110 attached to collector base 140 with the scissor mechanism can be lifted and the opposite end can rotate with respect to collector base 140 resulting in collector 110 tilting with respect to collector base 140. Tilting mechanism 144 can be angularly position solar collector 110 with respect to collector base 140 between 0° and 90°, as required for maximum solar exposure when deployed.

Rotating mechanism 146 can include a sealed slewing ring or other rotational bearing to allow 360° rotation with respect to collector base 140. Lifting mechanism 142 can include scissor mechanisms on two or more sides, depending on the weight of load supported, selected solar collector mechanisms, and desired stability. For example, illustrative lifting mechanism 142 in the various figures shows four scissor mechanisms, one for each side of the four-sided rail base 150.

Rails 122 can provide linear adjustment to solar panel mount 115 using a sliding mechanism. The sliding mechanism can include rail base 150 with slide tabs 152 that engage with slots 124 of rails 122, allowing for linear translation along the length of rails 122. In some embodiments, this linear translation can be adjusted and held at a desired position using cables 156. Cables 156 can also allow for selective individual movement or uniform movement of some or all solar collectors 110 in each solar array 100. Rails 122 may also include slot 128 to accommodate a sliding cover to protect solar collector 100 when not in use.

As shown in FIGS. 3-7A, solar collector array 100 can include several solar collectors 110 each mounted on a pair of rails 122. Rails 122 can be attached to support surface 130. Support surface 130 can be any area desired to accommodate solar collector array 100. Solar collector array 100 can be moved between a storage and/or transportation configuration, FIG. 3, and a deployed configuration, FIG. 7 (FIG. 7A shows FIG. 7 without solar collectors 110). FIGS. 3-7A generally illustrate a sequence for moving solar collector array 100 into a deployed configuration.

Beginning with FIG. 3 showing solar collector array 100 in the storage and/or transportation configuration, each adjustment mechanism of solar collector mount 115 can be adjusted to position solar collectors 110 parallel to and adjacent to support surface 130 and below the top surface of rails 122. FIG. 3A is solar collector array 100 of FIG. 3 without solar collectors 110. From the storage and or transportation configuration, alternate solar collectors 110 may be raised using lifting mechanism 142 as shown in FIG. 4. Each solar collector 110 can then be tilted to a desired angle using tilting mechanism 144 as shown in FIG. 5 and alternatively translated along rails 122 as shown in FIG. 6. For final positioning, solar collectors 110 can be rotated using rotating mechanism 146 to the desired rotational angle.

Thus, through the adjustment of collector mount 115, solar collectors 110 of solar collector array 100 can maximize solar collection based from support surface 130. Additionally, where support surface 130 is part of a mobile
structure, the collector mount 115 and rails 122 allow for protective, compact storage of solar collectors 110 and efficient solar power collection regardless of the rotational orientation of support surface 130. Spatially separating solar collectors 110 from each other using the various adjustment mechanisms can allow for minimal shadowing from adjacent collectors and rotational positioning and tracking for increased solar collection efficiency. For example, if support surface 130 is the roof of an RV, the RV may park pointing in any direction and easily deploy solar collector array 100 to achieve an efficient solar power collection from a relatively small surface area while still being able to protectively transport solar array 100.

[0034] In other embodiments with more limited surface area, such as the embodiment illustrated in FIGS. 8-11, solar collector array 200 can include several solar collectors 210 mounted to support surface 230. Solar collector array 200 can be moved between a storage and/or transportation configuration, FIG. 8, and a deployed configuration, FIG. 11. FIGS. 8-11 generally illustrate a sequence for moving solar collector array 200 into a deployed configuration. Solar collector mount 215 includes similar components of collector mount 115 described above, but modified for the smaller solar collector array 200 shown in FIGS. 8-11.

[0035] Beginning with FIG. 8 showing solar collector array 200 in the storage and/or transportation configuration, each adjustment mechanism of solar collector mount 215 can be adjusted to position solar collectors 210 parallel to and adjacent to support surface 230. From the storage and/or transportation configuration, alternate solar collectors 210 may be raised using lifting mechanism 242. Each solar collector 210 can then be tilted to a desired angle using tilting mechanism 244 and rotated using rotating mechanism 246 to the desired rotational angle.

[0036] Similarly, for long, narrow surfaces, some embodiments, such as the embodiment illustrated in FIGS. 12-15, solar collector array 300 can include several solar collectors 310 mounted on a pair of rails 322. Rails 322 can be attached to support surface 330. Solar collector array 300 can be moved between a storage and/or transportation configuration, FIG. 12, and a deployed configuration, FIG. 14. Solar collector mount 315 includes similar components of collector mount 115 described above, but modified for the smaller solar collectors 310 shown in FIGS. 12-15. FIGS. 12-15 generally illustrate a sequence for moving solar collector array 300 into a deployed configuration.

[0037] Beginning with FIG. 12 showing solar collector array 300 in the storage and/or transportation configuration, each adjustment mechanism of solar collector mount 315 can be adjusted to position solar collectors 310 parallel to and adjacent to support surface 330 and below the top surface of rails 322. From the storage and/or transportation configuration, each solar collector 310 can then be tilted to a desired angle using tilting mechanism 344. The solar collectors can be separated from each other by translation along slots 324 of rails 322 as shown in FIG. 14 to minimize shadowing from one collector to the next. For final positioning, solar collectors 310 can be rotated using rotating mechanism 346 to the desired rotational angle.

[0038] FIGS. 16-19 illustrate solar collector arrays 400 with adjustable mounts 415 deployed on trailer 470 with expandable sections 472, 474. Support surface 430 can be attached to trailer 470 with a hinge (not shown) at a top exterior corner on the side of trailer 470. Rails 422 can extend from support surface 430 providing support and pathways for protective cover 460 to be deployed and retracted along slots 428 of rails 422. Protective cover 460 can include one or more individual metal sectional doors that can be rolled into a generally cylindrical shape, similar to the retractable doors on a beverage truck. Protective cover 460 can be stored in the rolled form when retracted inside of eaves 464.

[0039] In some embodiments, protective cover 460 may be formed of any material and configuration sufficiently strong to prevent damage to solar collectors 410 by road debris. Additionally, protective covers 460 may also provide a theft deterrent similar to the protective covers of beverage trucks. Solar collectors 410 may be hidden during transport and storage, covered with protective cover 460, as shown in FIG. 16. FIG. 17 shows protective cover 460 retracted into eaves 464, revealing individual solar collectors 410.

[0040] Solar collector array 400 may be deployed using the steps, or similar steps, as discussed above, resulting in solar collectors 410 in the configuration shown in FIG. 18. Support surface 430 can then be rotated up to a generally horizontal position as shown in FIG. 19, with expandable sections 472, 474 under support surfaces 430.

[0041] FIG. 20 illustrates connected trailers 570, such as is used in mobile homes, mobile clinics, mobile classrooms, mobile work trailers (such as those commonly used at construction sites), etc., with solar arrays 590 formed from solar collectors 510 and connected to support surface 530, which are the roffs of trailers 570. Solar arrays 590 can include similar attachment and adjustment mechanisms as described above with other embodiments.

[0042] In some embodiments, as generally illustrated in FIG. 21, the deployment of the solar collector arrays can be automatic, with controller 640 driving actuators connected to each of the adjustment mechanisms and deployment mechanisms such as those discussed above. For example, lifting actuator 642 can move lifting mechanism 142, tilting actuator 644 can move tilting mechanism 144, rotating actuator can move rotating mechanism 646, sliding actuator 656 can move rail base 150 to affect translation of collector mount 115, as discussed above, and sliding cover actuator 662 can open and close the sliding covers. In some embodiments, sensors 648, such as a GPS unit and compass, can be used to automatically adjust the solar collector arrays for maximum efficiency in collecting solar power. Similarly, the actuators can be periodically adjusted to follow the course of the sun through the sky for improved solar power collection efficiency. The actuators can be any type of actuators capable of moving and adjusting the mechanisms in the ways discussed above to deploy a solar collector array.

[0043] In addition to any previously indicated modification, numerous other variations and alternative arrangements can be devised by those skilled in the art without departing from the spirit and scope of this description, and appended claims are intended to cover such modifications and arrangements. Thus, while the information has been described above with particularity and detail in connection with what is presently deemed to be the most practical and preferred aspects, it will be apparent to those of ordinary skill in the art that numerous modifications, including, but not limited to, form, function, manner of operation and use can be made without departing from the principles and concepts set forth herein. Also, as used herein, examples are meant to be illustrative only and should not be construed to be limiting in any manner.
1. A solar collector support system for an expandable array of rotatable solar collectors, the solar collector support system comprising:
   a plurality of solar collector mounts coupled to a support surface, the plurality of solar collector mounts being capable of changing relative spatial arrangement of each solar collector with respect to at least a neighboring solar collector, each solar collector mount including:
   a collector support, the collector support being capable of securing and supporting a solar collector;
   a rotating mechanism, the rotating mechanism being attached to the collector support, the rotating mechanism providing rotation of the collector support and the solar collector; and
   a sliding mechanism being attached to the rotating mechanism, the sliding mechanism being supported by the support surface, the sliding mechanism being capable of moving the collector support with respect to the supporting surface.

2. The solar collector support system of claim 1, further comprising a controller, the controller being cooperative with the plurality of solar collector mounts, wherein the controller is capable of changing the relative spatial arrangement of the collector supports, so that each collector support is capable of unobstructed rotation.

3. The solar collector support system of claim 2, wherein each solar collector mount further includes a tilt mechanism cooperative with at least one of the collector support, the rotating mechanism, and the sliding mechanism, and wherein each tilt mechanism can be operated by the controller so as to tilt each solar collector.

4. The solar collector support system of claim 1, wherein movement of the collector support with respect to the supporting surface includes at least one of:
   movement parallel to a front edge of the supporting surface;
   movement parallel to a side edge of the supporting surface; and
   movement perpendicular to the supporting surface.

5. The solar collector support system of claim 1, wherein the sliding mechanism includes:
   at least one rail coupled to the support surface, the at least one rail having a slot extending along the length of the at least one rail, and
   a sliding frame engaged in the slot and configured to slide along the length of the rail.

6. The solar collector support system of claim 1, wherein the plurality of solar collector mounts are movable between a consolidated configuration and a deployed configuration.

7. The solar collector support system of claim 6, further comprising retractable panels for covering the plurality of solar collector mounts when in the consolidated configuration.

8. The solar collector support system of claim 7, wherein the retractable panels protect the solar collector mounts from road debris and theft.

9. The solar collector support system of claim 6, wherein the plurality of solar collector mounts is positionable for maximum solar energy exposure when in the deployed configuration regardless of the orientation of the support surface.

10. The solar collector support system of claim 9, wherein the support surface is a roof of a mobile structure.

11. A method of using a solar array, comprising:
    providing a plurality of solar collectors in a consolidated position, the plurality of solar collectors operably connected to form a solar collector array, the plurality of solar collectors being coupled to a support surface; spatially separating the plurality of solar collectors, so as to permit unobstructed rotation of each solar collector; and rotating the plurality of solar collectors to increase solar power generation of the solar panel array.

12. The method of claim 11, wherein the spatially separating includes:
    moving at least one of the plurality of solar collectors with respect to the supporting by at least one of:
    movement parallel to a front edge of the supporting surface;
    movement parallel to a side edge of the supporting surface; and
    movement perpendicular to the supporting surface.

13. The method of claim 11, further comprising uncovering the plurality of solar collectors prior to the spatially separating.

14. The method of claim 11, further comprising, returning the plurality of solar collectors to the consolidated position.

15. The method of claim 11, wherein the spatially separating includes moving at least one of the plurality of solar collectors along a rail.

16. The method of claim 15, wherein the spatially separating includes moving each of the plurality of solar collectors along one or more rails.

17. The method of claim 11, wherein the support surface is roof of a mobile structure.

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