A photovoltaic roof structure is provided. The monolithic roof structure comprises a plurality of composite panels, photovoltaic modules and connectors, wherein the respective composite panels are comprised of an outer skin, an inner skin, and an insulation layer between the outer and inner skins, the photovoltaic modules are incorporated into the outer skin, and the connectors physically and electrically couple the composite panels to one another to form the roof structure.
STRUCTURAL INSULATED MONOLITHIC PHOTOVOLTAIC SOLAR-POWER ROOF AND METHOD OF USE THEREOF

CROSS REFERENCE TO RELATED APPLICATION[S]


BACKGROUND OF THE INVENTION

[0002] 1. Technical Field

[0003] This invention relates generally to solar panels, and in particular to a roof structure comprising solar panels.

[0004] 2. State of the Art

[0005] The design and construction of roofs for homes, buildings and other structures has undergone little advancement in technology over time. Currently, most of these roof structures are of similar design characteristics, that being, “stick-built” structures including roofs comprised of joists connected to rafters and covered with plywood sheets and then covered with a moisture barrier and other water-repellent material including steel sheeting, asphalt roofing, rubber roofing, composite shingles or tile shingles. When forces act on the roof, including dead loads, such as the weight of the roof itself, and live loads, such as high wind or heavy snow, are applied to these roofs, “point loads,” which occur at the intersecting points between the longitudinal (horizontal) support beams that are attached to the vertical walls that provide support for the roof, are generated that must be addressed at each individual joint.

[0006] These conventional roof structures are oftentimes assembled onsite and require significant time and cost for assembly. Moreover, these roof structures are susceptible to insect infestation, dry rot, mold and mildew and frequently do not provide the insulative properties against heating and cooling loss that is desired. Further, conventional roof structures do not provide any photovoltaic properties.

[0007] Accordingly, there is a need for an improved roof structure that addresses the above-mentioned problems. Specifically, there is a need for a roof structure that provides photovoltaic properties, can be quickly and easily assembled, exhibits greater insulative properties over conventional roofs, and improves the overall strength and stability of the roof over conventional roofs.

SUMMARY OF THE INVENTION

[0008] The present invention relates to solar panels and roof structures, and in particular, to a monolithic roof structure comprising an array of solar panels.

[0009] One aspect includes a roof structure comprising a plurality of composite panels; photovoltaic modules; and connectors, wherein the composite panel is comprised of an outer skin, an inner skin, and an insulation layer between the outer and inner skins, the photovoltaic modules are incorporated into the outer skin, and the connectors physically and electrically couple the composite panels to one another to form the roof structure.

[0010] Another aspect of the roof structure includes outer ribs, wherein the outer ribs are positioned between the skins near distal edges of the skins so as to contain the insulation material positioned between the skins. Each of the outer ribs may be configured in a c-shape and a top of the c-shape may engage the outer skin and a bottom of the c-shape may engage the inner skin.

[0011] Another aspect of the roof structure includes inner ribs, wherein the inner ribs may be positioned between the skins at regular intervals within the panel. Each of the inner ribs may be configured in an l-beam shape and a top of the l-beam may engage the outer skin and a bottom of the l-beam may engage the inner skin. Each of the inner ribs may further comprise openings positioned at regular intervals along the length of the l-beam shape.

[0012] Another aspect of the roof structure includes a reinforcement layer coupled to a bottom surface of the inner skin.

[0013] Another aspect of the roof structure includes a portion of the inner and outer skins extending beyond an outer rib, such that the portions of the inner and outer skins that extend beyond the outer rib can couple the panel to an adjacent structure, such as another panel, the support on which the panels rest, or the building itself.

[0014] Another aspect of the roof structure includes a honeycomb structure, wherein the honeycomb structure may be positioned between the inner and outer skins and may prevent the insulative material from penetrating within the honeycomb structure, such that the honeycomb structure and the transparency of the skins allows light to pass through the outer skin, the honeycomb structure, and the inner skin to shed light on the interior of the building.

[0015] Another aspect of the roof structure includes the support on which the roof structure rests being a steel support that is configured to support the weight of the plurality of composite roof panels thereon. The support may further comprise a cradle, wherein the cradle may be fixedly coupled to the steel support and may be structured to receive and secure the roof panels therein.

[0016] Another aspect of the roof structure includes a support panel configured to be positioned between two adjacent roof panels. The support panel may have a first end and a second end, the first end being elevated with respect to the second end. Thus, when one adjacent roof panel is coupled to the first end and the other adjacent roof panel is coupled to the second end, the first end raises the one adjacent roof panel coupled thereto above the level of the other adjacent roof panel coupled to the second end. The successive coupling of roof panels to one another with a support panel therebetween situates the roof panels an angle with respect to the horizontal. In this way, the roof panels may be angled from between 5 and 33 degrees, inclusive, with respect to the horizontal.

[0017] Another aspect of the roof structure includes the support panel further comprising a horizontal portion between the first and second ends, the horizontal portion forming a flat area between adjacent roof panels coupled to the support panel.

[0018] Another aspect of the roof structure includes electrical components, wherein the electrical components may be incorporated in the panels to electrically couple the photovoltaic modules to the panels, the panels to another, and the panels to the building, such that the solar energy absorbed by
each of the photovoltaic modules can be converted to electric energy and transported to the building to provide consumable power.

Another aspect of the roof structure includes a heat exchange system, wherein the heat exchange system may pump a heat transfer fluid through a closed loop, the closed loop passing through one or more panels and a water storage tank. The heat transfer fluid can enter the one or more panels and heat up by dissipating and carrying away heat generated by the photovoltaic modules. Then, the heated heat transfer fluid can enter the water storage tank and transfer heat to the potable water contained in the water storage tank to heat the potable water. Thereafter, the relatively cooled heat transfer fluid may exit the water storage tank and return to the one or more panels to be reheated.

Another aspect of the roof structure includes a method of forming a roof structure of a building, including the steps of forming a plurality of composite roof panels and composite support panels at a location; transporting the composite roof panels from the location to a building location; assembling the composite roof panels to one another with a composite support panel therebetween on top of the building at the building location; electrically coupling the composite roof panels to one another; and electrically coupling the composite roof panels to the building.

Another aspect includes providing a first skin; providing a second skin; placing inner ribs between the first and second skins at regular intervals; placing outer ribs between the first and second skins at distal ends of the skins; coupling the first skin to the second skin by adhering the first and second skins to opposing edges of the outer ribs; injecting insulation between the first and second skins; integrating photovoltaic modules having solar cells containing photovoltaic material therein onto the first skin; and electrically coupling the photovoltaic modules to the panel.

Another aspect includes the photovoltaic solar roof panel skins being produced using substrates of fiber reinforced plastic, metal, plywood or any substrate capable of meeting the structural requirements and building codes. A method of producing the sandwich panel skins would be the use of high speed automated continuous or static press. Once the skins are produced, a hydraulic press is used to inject structural insulation rigid foam between the two skins or by adhesively bonding the two skins to pre-formed rigid foam insulation planks. When assembled at the jobsite, the photovoltaic solar roof panels are joined in such a way as to form a monolithic solar roof distributing stress loads throughout the entire roof in such a manner as to eliminate point loads that are present in conventional construction methods. The monolithic photovoltaic solar roof construction method of this invention will allow for roofs to be built exhibiting superior strength and durability, ease of assembly, with a much higher “R-Value” and with the ability to produce electricity generated by photovoltaic cells. A roof of this design will be substantially less in cost when compared to roofs built using conventional building methods with conventional photovoltaic solar systems “bolted on” as a separate component.

Another aspect includes the monolithic roof structure defining a totally different design, manufacturing process, and assembly method to produce a monolithic, structurally insulated, photovoltaic solar roof. The design, materials of choice, and manufacturing techniques were born within the aerospace industry. Aerospace concepts, as applied to the invention submitted, will allow roofs to be produced that will exhibit tremendous improvements over existing production and assembly methods by using a monolithic design, low cost rapid automated manufacturing process and modular prefabrication assembly method, thusly reducing production and on-site assembly time/cost.

The foregoing and other features and advantages will be apparent from the following more detailed description of the particular embodiments of the invention, as illustrated in the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A is a perspective view of a monolithic roof structure on a building in accordance with the present invention.

FIG. 1B is a perspective view of a monolithic roof structure on a building in accordance with the present invention.

FIG. 2 is a front perspective sectional view of a panel of the roof structure in accordance with the present invention.

FIG. 3A is an exploded cross-sectional view of the panel in accordance with the present invention.

FIG. 3B is a sectional side view of a reinforcement member within the panel in accordance with the present invention.

FIG. 4 is a side view of an embodiment of the interaction of the panels in accordance with the present invention.

FIG. 5A is a side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

FIG. 5B is an exploded side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

FIG. 5C is a side view of an embodiment of the interaction between the panel and vertical support member in accordance with the present invention.

FIG. 6 is a side view of the panel in accordance with the present invention.

FIG. 7 is a top view of the panel of the roof structure in accordance with the present invention.

FIG. 8A is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention, including an exploded view of a component of the monolithic roof structure.

FIG. 8B is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention.

FIG. 9 is a side view of the monolithic roof structure in accordance with the present invention.

FIG. 10 is a schematic of the heat exchanger system in accordance with the present invention.

FIG. 11 is a sectional, interior view of a panel of the roof structure in accordance with the present invention.

FIG. 12 is a side view of an embodiment of the interaction of the panels in accordance with the present invention.

FIG. 13 is a sectional, side view of an embodiment of the monolithic roof structure in accordance with the present invention.

FIG. 14 is a top view of an embodiment of the monolithic roof structure in accordance with the present invention.
FIG. 15 is a perspective view of an embodiment of the monolithic roof structure in accordance with the present invention.

FIG. 16 is a perspective view of an embodiment of the monolithic roof structure in accordance with the present invention.

FIG. 17 is a side view of an embodiment of the monolithic roof structure in accordance with the present invention

DETAILED DESCRIPTION OF EMBODIMENTS OF THE INVENTION

As discussed above, embodiments relate to solar panels and roof structures, and in particular, to a monolithic roof structure comprising an array of solar panels.

As shown in FIGS. 1A and 1B, a structure building 10, representative of any commercial, military, recreational, residential building, or the like, includes a monolithic roof structure 12 according to an embodiment of the present disclosure. The monolithic roof structure 12 comprises at least one solar panel 14, and in some cases the monolithic roof structure 12 comprises an array of solar panels 14. The panels 14 may have placed thereon a solar module 14a, as shown in FIGS. 3A and 8A, comprising one or more photovoltaic cells that convert solar energy to electric energy. The panels 14 may have a plurality of solar modules 14a placed thereon, as shown in FIGS. 3A and 15. The panels 14 may extend from one end of the roof of the building 10 to an opposing end of the roof, such that a panel 14 extends from one side of the building 10 to the other, for example, as shown in FIGS. 1A and 1B.

As shown in FIG. 2, the solar panel 14 may be a sandwich panel comprised of photovoltaic solar cells 14a incorporated into, or placed on top of, an outer skin 16 and an insulation layer 20 sandwiched between the outer skin 16 and an inner skin 18. The solar panel 14 may be manufactured using high-speed continuous laminating machines and static presses and by injecting a foam core, the insulation layer 20, between the skins, 16 and 18. The solar panel 14 may alternatively be created by adhesively bonding pre-formed rigid foam insulation planks, not shown, to the skins, 16, and 18, skin 16 adhered to one side of the plank and skin 18 adhered to the opposing side of the plank, thus producing the sandwich panel 14. The skins 16 and 18 themselves may be produced using fiber-reinforced thermoplastics, fire retardant fiber-reinforced thermoset, water based resin, metal, plywood, or other substrate capable of meeting the structural requirements and building construction codes. The insulation layer 20 may be a fire-retardant foam or other material having fire-retardant properties. The insulation layer 20 may be made from EPS, XPS, and/or Pu foam.

As shown in FIG. 3A, the panel 14 may further comprise a side reinforcement rib 22 and/or an interior reinforcement rib 22. The reinforcement ribs 22 and 23 may run longitudinally with the length of the panel 14 and may have an I-beam cross-sectional shape, as may be the case for reinforcement ribs 22, or a C-shaped cross-sectional shape, as may be the case for reinforcement ribs 23. The I-beam shape and the C-shape help to strengthen the rigidity of the monolithic solar panel 14. Although the reinforcement rib 22 is shown to have an I-beam cross-sectional shape, it is contemplated that the reinforcement ribs 22 and 23 can have any suitable cross-sectional shape that provides added rigidity and strength to the monolithic solar panel 14. During the formation of the monolithic solar panel 14, a plurality of reinforcement ribs 22 and 23 can be placed at regular or irregular intervals in between the skins 16 and 18. The reinforcement ribs 22 and 23 may be coupled to the skins 16 and 18 by adhesive layer 19. Thereafter, the insulation layer 20 is placed around the reinforcement ribs 22 and between reinforcement ribs 23. The insulation layer 20 may serve to further secure the reinforcement ribs 22 in place. In addition, a reinforcement panel 17 may be coupled to the inner skin 18 to further strengthen the panel 14 or provide additional fire retardant property. The reinforcement panel 17 may be, for example, magnesium oxide, a cement-based material or a drywall-based material. Embodiments of the panel 14 may comprise the reinforcement panel 17 being comprised of magnesium oxide that is combined with cement and formed into strong and thin boards and/or panels, such as, but not limited to, magnesia board or magnesia wallboard.

As shown in FIG. 3B, the reinforcement ribs 22 may have openings 24 in the middle portion thereof, the openings 24 providing relief to the insulation layer 20. For example, if the insulation layer 20 is injected in between the skins 16 and 18, the openings 24 allow the insulation layer 20 to expand through the openings 24, so as to not expand upward or downward unnecessarily, which may crack or displace the skins 16 and 18 during the manufacture of the solar panel 14. The reinforcement ribs 22 and 23 can be comprised of fiber-reinforced thermoplastics and/or fire retardant fiber-reinforced thermoset, or any other lightweight material capable of increasing the rigidity and strength of the panel 14.

Once formed, each monolithic solar panel 14 may comprise a portion of the overall monolithic roof structure 12. In fact, the monolithic roof structure 12 may be assembled from a plurality of monolithic solar panels 14 being coupled together, such as in side-by-side configurations or in end-to-end configurations, or varied combinations of both. As shown in FIG. 4, the outer skin 16 and inner skin 18 of one panel 14 may overlap the edge of the panel 14. An adjacent panel 14 may have indented portions on the outer skin 16 and inner skin 18 to receive the overlapping portions of the one panel 14. The overlapping portions of the respective skins 16 and 18 may couple to the adjacent panel 14 by sliding over the indented portions of the adjacent panel 14. Once coupled together, the one panel 14 and the adjacent panel 14 may be fixedly attached to one another by thermowelding the respective skins 16 and 18 together. In the alternative, the panel 14 and the adjacent panel 14 may be fixedly attached to one another by bolts or rivets or caps. Further in the alternative, the panel 14 and the adjacent panel 14 may be fixedly attached to one another by structural adhesive. Additionally in the alternative, the panel 14 and the adjacent panel 14 may be fixedly attached to one another by cam lock. In one particular embodiment, the panel 14 and the adjacent panel 14 may be fixedly attached to one another by embedding electrical "resistance" wires, not shown, by means of thermo-forming the wires within the respective roof panel skins 16 and 18 in such a manner that when electrical current is applied, the wires are heated thus welding the roof panel 14 to the adjacent roof panel 14. The resistance wires remain within the respective roof panel skins 16 and 18 and, if necessary, the roof panels 14 may be separated by reversing this process. At least in these ways, the panels 14 are coupled together to form a monolithic roof structure 12.

As shown in FIG. 12, adjacent panels 14 may alternatively be coupled together by use of a flange 25 and C-shaped end 27. For example, an end of one panel 14 may
have coupled thereto a flange 25, such that one end of the flange 25 is fixedly coupled to the one panel 14. The flange 25 may be coupled to the one panel 12 by adhesive 19, by bolt, rivet, or cam locks, by welding, or by therm-forming, as described above. An adjacent panel 14 may have fixedly coupled thereto a c-shaped end 27 that may be configured to engage the open end of the flange 25. The c-shaped end 27 may be coupled to the adjacent panel 14 by adhesive 19, by bolt, rivet, or cam locks, by welding, or by thermo-forming, as described above. Under the condition that the adjacent panel 14 is advanced toward the one panel 14 to couple together the one panel 14 and the adjacent panel 14, the c-shaped end 27 is configured to slide within the flange 25 to secure the c-shaped end 27 within the flange 25 to thereby secure the one panel 14 to the adjacent panel 14. When engaged, the flange 25 and the c-shaped end 27 may be further coupled together by adhesive 19, by bolt, rivet, or cam locks, by welding, or by thermo-forming, as described above.

[0054] As shown in FIGS. 1 and 14, the monolithic roof structure 12 may comprise as many individual roof panels 14 as are necessary to construct a roof for a particular building 10. Thus, each building 10 will be unique in its implementation of the roof structure 12. Nonetheless, regardless of the number of roof panels 14 needed to construct the roof for the individual building 10, the properties of the roof structure 12 remain consistent from building to building. For example, the incorporation of the photovoltaic solar cells 14r into the respective outer skin 16 of each of the all-composite roof panels 14, the roof panels 14 having a limited number of internal reinforcement ribs 22 to strengthen the panels 14, allows the roof structure 12 to not only convert solar energy to electric energy to power the building, but also to be sufficiently strong to carry its own weight as well as all the external stress loads generated throughout the entire roof 12 and transfer those forces out to the vertical walls of the building 10 and down to the foundation on which the building 10 rests.

[0055] As shown in FIG. 5A, a vertical wall 30 may be coupled to the roof structure 12, and specifically the monolithic solar panel 14, by way of vertical connectors 32. The vertical connectors 32 may be attached to the monolithic solar panel 14 by thermowelding the vertical connector 32 to the solar panel 14, by bolting or riveting the vertical connector to the solar panel 14, or by connecting the vertical connector 32 to the solar panel 14 by structural adhesive or cam locks. Thereafter, the vertical connector 32 may be fixedly coupled to the vertical wall 30 by cam locks, bolts or rivets. Moreover, it is contemplated that although several means for connecting the solar panel 14 to the vertical wall 30 are disclosed, it will be apparent to those of ordinary skill in the art to incorporate any feasible means now known or later developed for connecting the solar panel 14 to the vertical wall 30, and for that matter, connecting the monolithic solar panel 14 to any vertical support structure, whether it be the exterior vertical wall 30 or an internal vertical support structure. This design dissipates fatigue and dynamic point load conditions throughout the entire structure rather than transmitting loads directly to the joints as in conventionally designed framed structures.

[0056] As shown in FIG. 5C, for pitched roofs, the monolithic roof structure 12 may further comprise a roof crown attachment 34. The roof crown attachment 34 is structured to couple to the main support beam 36 or column of the building. The roof crown attachment 34 is configured to receive and have coupled thereto a monolithic solar panel 14 on each of its sides. The solar panels 14 may be coupled to the roof crown attachment 34 by cam locks 35, or the solar panels 14 may be coupled to the roof crown attachment 34 by thermowelding the solar panels 14 to the roof crown attachment 34, by bolting or riveting the monolithic solar panels 14 to the roof crown attachment, or by connecting the solar panels 14 to the roof crown attachment 34 by structural adhesive. Additionally in the alternative, the panel 14 and the adjacent panel 14 may be fixedly attached to one another by cam locks 35.

[0057] The physical configuration of the monolithic roof structure 12 reduces the number of vertical and horizontal support members that are typically needed to support a building’s roof, such as truss members, beams, and columns. As configured, the structural strength of the panels 14 allow the monolithic roof structure 12 to carry the generated stress loads described above equally within the outside skin 16 and inside skin 18 of the composite sandwich panels 14 forming the monolithic solar roof structure 12. In one regard, the stress loads exhibited on the monolithic solar roof structure 12 causing tension and compression on the panels 14 react as though the roof 12 is not comprised of several inter-connected panels 14 but rather as a single monolithic roof structure 12 supporting the total weight of the roof 12 and resisting all external forces.

[0058] Under the condition that the monolithic solar roof panels 14 are produced using fiber reinforced thermoplastic skins, the panel ends may be heated and “post-formed” creating radius corner bends to any degree desired or by thermo-forming the solar roof panel edge creating “closed” edges or tongue groove joints for connecting one solar roof panel 14 to another. Additionally, the ability to thermoform the thermoplastic skins 16 and 18 will allow for the skins 16 and 18 to be shaped prior to the process of injecting the insulation layer 20 in between the skins 16 and 18.

[0059] For example, as shown in FIG. 6, the outer skin 16 may be formed to look like conventional roof shingles 40 and the inner skin 18 may be formed with cosmetic film to look like tongue and groove paneling. When the monolithic solar roof panels 14, as described, are installed, no additional fabrication such as a vapor barrier, plywood, shingles, drywall or paint is required. The solar panels 14 will be produced with materials that will meet all International, U.S. and local Class A fire and smoke building codes.

[0060] As shown in FIG. 2, the individual panels 14 in the array of panels 14 forming the composite monolithic roof structure 12 may further comprise electrical conduits 26 placed within the insulation layer 20 to allow the solar panel 14 to electrically couple to the adjacent solar panel 14 by way of the wiring connection 28. In this way, each of the photovoltaic cells or modules 14a on the outer skin 16 can be electrically coupled to one another and the electricity produced by the photovoltaic modules 14a can be harnessed and used by the building 10. The photovoltaic cells or modules 14a contain photovoltaic material, such as, but not limited to, silicon, which can be in the form of crystalline silicon, polycrystalline silicon, or amorphous silicon, cadmium telluride, and/or a solar ink, a solar dye, or a conductive plastic. The photovoltaic material in modules 14a can be any material that converts optical radiation into electrical charge.

[0061] A photovoltaic material converts light rays into electrical charge. Light rays can be sunlight, but are not limited in this aspect. The photovoltaic material in modules 14a generates electrical charge, or current, when sunlight is incident on the module 14a and the photovoltaic material therein. Embodiments of the roof structure 12 include the electrical
charge generated by light incident on the photovoltaic material within the modules 14a on the panels 14 being harvested and stored in a battery, a plurality of batteries, rechargeable batteries, or in a fuel cell. Embodiments of the roof structure 12 include the electrical charge generated by light incident on the photovoltaic material within the modules 14a on the panels 14 being harvested and directly consumed.

In one embodiment of the structural insulated photovoltaic solar roof 12, the roof 12 may be comprised of several monolithic solar panels 14, the panels 14 being typically 4 to 10 inches thick and exhibiting insulative properties, typically R-42, being 4 ft. to 10 ft. wide, and having lengths of 12 ft. to 60 ft., as shown in FIG. 14, and as dictated by the configuration of the needs of the roof 12 of the building 10.

In the alternative to the electrical conduits 26 being placed within the solar panel 14, the wiring and wiring connection 28 can be placed on the exterior of the solar panels 14 and fully exposed to the naked eye, or the wiring and wiring connection 28 can be placed within a removable cover plate incorporated into the solar panels 14. As shown in FIG. 5B, the monolithic solar panel 14 may also be physically and electrically coupled to any internal or external vertical support structure 31 or 36.

Because the individual panels 14 comprising the structural insulated photovoltaic solar roof 12 can be fabricated away from the jobsite where the building 10 is being constructed/erected and transported to the jobsite, the assembly of the roof 12 at the jobsite will require no additional fabrication. For example, as shown in FIG. 7, for pitched roofs, perimeter shingles 40 on the roof 12 surrounding the photovoltaic solar cells 14a and panel edges may be factory installed. The structural insulated photovoltaic solar roof panels 14 are manufactured to be as light as 2.5 lbs. per sq. ft., including the weight of the solar modules 14a. These panels 14 can thus be easily transported to the assembly site and can be lifted into place and secured in place to the adjacent panels 14 or the vertical support walls 30 of the structure, as described above.

The roof 12 may also have fire protection sprinklers incorporated within the sandwich roof panels 14. The fire sprinklers can be installed internally between the sandwich panel skins 16 and 18 prior to the process of placing the insulation layer 20 between the respective skins to form the panel 14. Attachment fittings would protrude out of the inner panel skin 18 to facilitate the fastening and attachment of the fire sprinkler head down inside the interior space of the building 10. The sprinkler pipes forming the fire sprinkler system can be inter-connected from panel 14 to adjacent panel 14, much like the electrical wiring connections 38 within the respective panels 14, until the sprinkler pipes and fire sprinkler system is connected to the vertical main water supply pipe of the building 10.

As an additional option, the solar roof panels 14, as herein described, may have skylights or localized translucent areas formed therein. The translucent area may be formed by inserting honeycomb, or other spacious and see-through material, between the two sandwich panel skins 16 and 18 prior to the injecting or placing the insulation layer 20 between the respective skins 16 and 18 to form the panel 14. Thus, if the insulation layer 20 is injected between the skins 16 and 18, the honeycomb prevents the insulation layer 20 from creeping into the honeycomb between the skins 16 and 18 as a result, the honeycomb prevents the insulation layer 20 from passing through the skins 16 and 18 and the honeycomb structure, which thereby produces a skylight or localized translucent area through which ambient light may pass.
to an average of the incidence angle over the course of the year to thus minimize the variance of the perpendicular line to the surface of the monolithic solar panels 14 from the angle of the ray of sunshine. In certain embodiments, the predetermined angle may be between 5 and 33 degrees, inclusive, from the horizontal.

As shown in FIG. 8A, the panel 14 is angled at the predetermined angle. The base of the support panel 42 connects to the base of the panel 14. The top of the support panel 42 connects to the top of the adjacent panel 14. This configuration continues until the monolithic roof structure 12 is formed. The panels 14 and the support panel 42 can be coupled together in a similar fashion to the coupling of individual panels 14 described above and shown in FIG. 4. Support panel 42 can also be comprised of the same materials used to fabricate the solar panels 14. For example, the support panel 42 may comprise inner and outer skins 16 and 18, as well as reinforcement panel 17. The support panel 42 may have photovoltaic cells and modules 14a placed thereon to aid in the conversion of solar power to electric power. Embodiments of the roof structure 12 may include the support panels 42 being adjustable during installation of the panels 14 to allow the panels 14 to assume varied angles from the horizontal. The support panels 42 can also include the honeycomb structure described above to create a skylight in the support panels 42, if desired.

Alternatively, as shown in FIG. 8B, the support panel 42 and the individual panels 14 can be coupled together by braces 44 shown in the cut outs. The braces 44 may be coupled to the panels 14 by rivets, bolts, structural adhesive, welding, or like manner. Further, as shown in FIG. 12, the lower joint 43 may serve to couple the lower end of the panel 12 to a lower end of the vertical support panel 42.

Further in the alternative, as shown in FIG. 9, the photovoltaic solar panels 14 can be arranged as described above, but may also include a flat section 46 coupled to the bottom of the support panel 42 and the adjacent monolithic solar panel 14. In this configuration, the monolithic roof structure 12 may accommodate air conditioning and heating units, vents, and/or service walkways in the flat section 46. Alternatively, as shown in FIG. 15, the length of one of the plurality of solar panels 14 may be shortened, with respect to the edge of the building 10, so as to leave a flat section 11 between the panel 14 and the edge of the building 10, whereon an A/C unit, or other similar appliance may be accommodated. The flat sections 11 or 46 can be comprised of the same materials used to fabricate the monolithic solar panels 14. The flat section 46 can also include the honeycomb structure described above to create a skylight in the flat section 46, if desired. Also, the flat section 46 may, but typically does not, include photovoltaic modules 14a thereon.

With regard to FIGS. 16 and 17, each panel 14 may be supported on a support beam 19 that runs along an edge of the building 10 or runs between edges of the building 10, such that each side of each panel 14 may rest upon and be supported by the support beam 19. Support beam 19 may be formed of a strong and sturdy material, such as steel, to provide support to the collective roof structure 12, formed of individual panels 14 coupled together, as described herein. Support beam 19 may be integral with the building 10, such that the building 10 supports the weight of the support beam 19 and the roof structure 12 that is placed thereon. Alternatively, the support beam 19 may be fixedly coupled to the building 10 by fasteners, bolts, or other like coupling means that fasten the support beam 19 to the building 10 to allow the building 10 to support the support beam 19 and the roof structure 12 that will be placed thereon. The support beam 19 may run along the inner surface of the perimeter vertical walls of the building 10 or may also run along the top surface of the perimeter vertical walls of the building 10. The support beam 19 may also run between opposing vertical walls of the building 10. The support beam 19 may also run between other support beams 19 in a grid-like pattern, if necessary. In fact, the support beam 19 may assume any configuration with respect to the building 10 that allows the roof structure 12 to be placed thereon and supported thereby to provide a solar-powered roof for the building 10. Moreover, as depicted in FIG. 17, a cradle 19a may be welded, or otherwise adhered, by using a welding material 19b, to the top of the support beam 19. Thereafter, the panel 12 and support member 42 may be placed within, supported by, and/or secured to the cradle 19a. The panel 12 and the support member 42 may thereafter be welded, or otherwise adhered, to the cradle 19a. Optionally, the panel 12 and the support member 42 may be welded, or otherwise adhered directly to the top of the support beam 19 without the use of the cradle 19a.

As shown in FIGS. 10 and 11, embodiments of the monolithic roof structure 12 may include a heat exchanger system 50 built into the panels 14. Piping 52 of the heat exchanger system 50 may be installed internally between the sandwich panel skins 16 and 18 prior to the injection or placement of the insulation layer 20 between the skins 16 and 18. Alternatively, the piping 52 may be placed between the photovoltaic modules 14a and the outer skin 16 of the respective panels 14.

The heat exchanger system 50 recirculates fluid, in certain embodiments the fluid is glycol, through the piping 52 to provide a dual function. First, the heat generated by the photovoltaic solar modules 14a can be dissipated by the fluid flowing through the piping 52, which dissipation of heat lowers the operating temperature of the solar modules 14a, which increases the efficiency of the photovoltaic modules 14a thus increasing not only the total wattage of electricity produced by the modules 14a but also the life expectancy of the photovoltaic solar modules 14a. Second, the heated fluid that has passed through the panel 14 may be used in the heat exchange system 50 to heat water in a storage tank 54 that is used by the building 10. Specifically, potable cold water enters the system 50 from a main water line and travels into the storage tank 54. The cold water in the storage tank 54 is gradually heated by the fluid that has been heated by the panel 14 and flows through the pipes 52 within the storage tank 54. As the potable water heats up, it rises within the storage tank 54 and flows out of the storage tank as hot water. The hot water travels to the water heater 56 and is stored therein until needed by the building 10. Similarly, the fluid that passes through the pipes 52 within the storage tank 54 and dissipates its heat to the potable water in the storage tank 54 is pumped by a pump back into the panel 14. Upon entering the panel 14, the fluid heats up by dissipating the heat from the solar modules 14a on the panel 14. Once heated, the fluid passes back into the pipes 52 that lead into and coil within the storage tank 54. The heat exchange between the fluid in the pipes and the potable water within the tank 54 begins again, or more accurately continues. As a result of the heat exchange system 50, the building 10 is more efficient. Specifically, instead of requiring the water heater 56 to heat potable water from the temperature of the cold main water line to the desired hot.
temperature, the water heater 56 need only maintain, or even simply store, the potable water that has been heated in the storage tank 54 and transported to the water heater 56. Thus, the water heater 56 need not work nearly as hard as it otherwise might have to, thus requiring less energy to operate the water heater 56.

[0076] A method of manufacturing and assembling the monolithic roof structure 12 will hereinafter be described. The panel 14 comprising the roof structure may be manufactured by providing an outer skin, providing an inner skin, and providing a rib therebetween to secure the outer skin apart from the inner skin and provide structural rigidity to the panel. Thereafter an insulating layer may be injected or otherwise placed within the inner and outer skins. A photovoltaic module may be coupled or incorporated in the outer skin of the panel to thus receive the rays of the sun and convert solar energy to electric energy. The panel may further be manufactured by providing a reinforcement layer on the inner skin to further reinforce the strength and rigidity of the panel.

[0077] Manufacturing of the panel may further include forming the shape and texture of the outer and inner skins. Manufacturing of the panel may further include placing a honeycomb structure between the skins, such that the insulating layer is prohibited from entering the honeycomb structure. Manufacturing of the panel may further include placing electrical wiring within the panel, the electrical wiring being configured to connect to wiring of adjacent panels or to the existing wiring of the building on which the panels will be placed. Manufacturing of the panel may further include placing plumbing within the panel, the plumbing being configured to connect to the plumbing of adjacent panels or to the existing plumbing of the building on which the panels will be placed. The plumbing of the panels may further comprise being outfitted to have connected thereto sprinkler heads, such that the sprinkler heads and plumbing form part of a fire prevention and fire extinguisher system.

[0078] The building may have assembled thereon a roof structure comprising one or more panels described above. The roof structure may be formed on the building by forming a predetermined number of panels at a location, transporting the panels from the location to a location of the building, moving the panels up to the level of the roof of the building, and assembling the panels in a preconfigured orientation by coupling the panels to one another or to support structures positioned between respective panels. The panels may be assembled side-by-side in a horizontal fashion, as described above, or may also be assembled in a side-by-side fashion wherein the individual panels are angled with respect to the horizontal, as described above. The individual panels may be angled with respect to the horizontal by coupling the panels to a support member that positions one end of a panel above an opposing end and at the same time allows adjacent panels to connect to the support member placed between the adjacent panels. In other words, the support member supports a lower end of one panel while likewise supporting an upper end of an adjacent panel. The panels may further be assembled by connecting electrical connections between adjacent panels and between panels and the electrical connections within vertical members of the building. The panels may further be assembled by connecting plumbing between adjacent panels and between panels and the plumbing in the vertical members of the building. The panels may be adjusted to place the panels at the best angle with respect to the horizontal to permit the photovoltaic modules on the respective panels to best absorb the solar energy and convert that energy to electricity. The panels may further be assembled to create a monolithic roof structure that may not require vertical support members connected thereto within the interior space of the building, thus creating more usable space within the building.

[0079] The embodiments and examples set forth herein were presented in order to best explain the present invention and its practical application and to thereby enable those of ordinary skill in the art to make and use the invention. However, those of ordinary skill in the art will recognize that the foregoing description and examples have been presented for the purposes of illustration and example only. The description as set forth is not intended to be exhaustive or to limit the invention to the precise form disclosed. Many modifications and variations are possible in light of the teachings above without departing from the spirit and scope of the forthcoming claims.

What is claimed is:

1. A composite roof panel, the composite roof panel comprising:
   - an outer skin;
   - an inner skin;
   - an insulation material positioned between the inner and outer skins; and
   - photovoltaic cells containing photovoltaic materials integrated onto the outer skin.

2. The panel of claim 1, further comprising outer ribs, wherein the outer ribs are positioned between the skins near distal edges of the skins so as to contain the insulation material positioned between the skins.

3. The panel of claim 2, wherein each of the outer ribs is configured in a c-shape and a top of the c-shape engages the outer skin and a bottom of the c-shape engages the inner skin.

4. The panel of claim 1, further comprising inner ribs, wherein the inner ribs are positioned between the skins at regular intervals within the panel.

5. The panel of claim 4, wherein each of the inner ribs is configured in an l-beam shape and a top of the l-beam engages the outer skin and a bottom of the l-beam engages the inner skin.

6. The panel of claim 5, wherein each of the inner ribs further comprises openings therein positioned at regular intervals along the length of the l-beam shape.

7. The panel of claim 1, further comprising a reinforcement layer coupled to a bottom surface of the inner skin.

8. The panel of claim 1, wherein a portion of the inner and outer skins extends beyond an outer rib, such that the portions of the inner and outer skins that extend beyond the outer rib are structured to couple the panel to an adjacent structure.

9. The panel of claim 1, further comprising a honeycomb structure, wherein the honeycomb structure is positioned between the inner and outer skins and prevents the insulation material from penetrating within the honeycomb structure so as to allow light to pass through the outer skin, the honeycomb structure, and the inner skin.

10. A roof structure of a building, the roof structure comprising:
   - a plurality of composite roof panels having an outer skin, an inner skin, and an insulation layer therebetween;
   - a support; and
   - photovoltaic modules,
   wherein one or more of the plurality of roof panels are coupled together and positioned on and collectively sup-
ported by the support, and wherein one or more of the photovoltaic modules are integrated onto the outer skin of each panel.

11. The roof structure of claim 10, wherein the support is a steel support and is configured to support the plurality of composite roof panels thereby.

12. The roof structure of claim 11, further comprising a cradle, wherein the cradle is fixedly coupled to the steel support and is structured to receive and secure the roof panels therein.

13. The roof structure of claim 10, further comprising a support panel configured to be positioned between two adjacent roof panels and having a first end and a second end, the first end being elevated with respect to the second end, wherein one adjacent roof panel couples to the first end and the other adjacent roof panel couples to the second end, such that the first end raises the one adjacent roof panel coupled thereto above the level of the other adjacent roof panel coupled to the second end.

14. The roof structure of claim 13, wherein successive coupling of roof panels to one another with a support panel therebetween situates the roof panels at an angle with respect to the horizontal.

15. The roof structure of claim 14, wherein the roof panels are angled from between 5 and 35 degrees, inclusive, with respect to the horizontal.

16. The roof structure of claim 14, wherein the support panel further comprises a horizontal portion between the first and second ends, the horizontal portion forming a flat area between adjacent roof panels coupled to the support panel.

17. The roof structure of claim 10, further comprising electrical components, wherein the electrical components are incorporated in the panels to electrically couple the photovoltaic modules to the panels, the panels to one another, and the panels to the building, such that the solar energy absorbed by each of the photovoltaic modules is converted to electric energy and transported to the building to power the building.

18. The roof structure of claim 10, further comprising a heat exchange system, wherein the heat exchange system pumps a fluid through a closed loop that passes through one or more panels and a water storage tank, the fluid entering the one or more panels and heating up by dissipating and carrying away heat generated by the photovoltaic modules, the heated fluid thereafter entering the water storage tank and transferring heat to the potable water contained in the water storage tank to heat the potable water, the cooled fluid thereafter exiting the water storage tank and returning to the one or more panels to be reheated.

19. A method of forming a roof structure of a building comprising:

forming a plurality of composite roof panels and composite support panels at a location;
transporting the composite roof panels from the location to a building location;
Assembling the composite roof panels to one another with a composite support panel therebetween on top of the building at the building location;
electrically coupling the composite roof panels to one another; and
electrically coupling the composite roof panels to the building.

20. The method of claim 19, the forming a plurality of composite roof panels further comprises:

providing a first skin;
providing a second skin;
placing inner ribs between the first and second skins at regular intervals;
placing outer ribs between the first and second skins at distal ends of the skins;
coupling the first skin to the second skin by adhering the first and second skins to opposing edges of the outer ribs;
injecting or placing insulation between the first and second skins;
integrating photovoltaic modules having solar cells containing photovoltaic material therein onto the first skin; and
electrically coupling the photovoltaic modules to the panel.