

Field of the Invention

This invention generally relates to roof and wall systems, and specifically to a system and a method for assembling and mounting a multiple functional roof and wall system on or as part of a building structure to provide dynamic building thermal control, collect warm or cool fluid, and generate electricity.

Background of the Invention

As living standard increases, a lot of energy is being used to air-conditioned the building, to heat the water, to chill the food, and for other purposes mostly for the comfort of the people in the building. Though some of the purposes are well justified, energy demand causes fast depletion of natural resources, and thus better ways of harnessing energy from alternate and renewable sources are needed. It is also important to improve energy performance of the building, reduce energy need of the appliances, and readjust the energy consumption habit for sustainable lifestyle. To achieve the objective, many countries throughout the world have setup policies, legislation and incentives to encourage or enforce the architect to rethink and redesign the building energy efficiency, and the indoor environmental conditions.

Many products have been developed, tested and deployed. Photovoltaic system and solar water heating system have both been installed and used on the roof for many years. Both serve their function well and receive great acceptance. However, both products are competing for roof space which is limited and expensive in congested city areas. It is thus not surprising that both systems should be integrated as one to complement each other. The solar collector itself can be a good choice of roofing and wall material as it comes with large flat surface, and with good tensile strength. This invention provides a cost effective roof and wall material, which also generates energy from solar thermal and PV cells attached to the outer layer, regulates the temperature of the walls, and allows heating of water and/or space. It is highly modular and easily installed on most building structure.

Prior arts

GB2340993 discloses an integrated photovoltaic composite panel which incorporates photovoltaic cells into steel clad roofs and facades to form multi-purpose product. It consists of a core structure including an insulated corrugated or castellated metallic-coated steel sheet, and an outer skin comprising a layer of amorphous or crystalline silicon PV cells, a channel being formed between the core structure and the outer skin to provide ventilation and or cooling for the PV cells. This disclosure is good for the circulation of air through the channel and hence cools the PV cells. However, the

circulation of water is challenging as there are potential leakage between the steel sheet and the underside of the PV cells.

US 6,295,818 B1 discloses a flexible solar power assembly, which consists of a flexible photovoltaic device attached to a flexible thermal solar collector. The solar power assembly can be rolled up for transportation and then unrolled for installation on a surface, such as the roof, or side wall of a building or other structure, by the use of adhesive and/or other types of fasteners. This disclosure provides ease of installation, but the thermal energy collection efficiency is limited by the polymer used by the solar thermal collector. The PV cell temperature will remain high, and causes a reduction in PV energy harnessing efficiency.

US 7,342,171 B2 discloses an integrated solar or photovoltaic roofing component and panel that can be attached to a roofing surface. The integrated component and panel includes a flexible membrane sheet and a plurality of elongated solar or photovoltaic modules. The plurality of elongated photovoltaic modules is attached to a top surface of the flexible membrane sheet. This disclosure can be unrolled onto a roof of a building structure and installed and properly connected with fewer electrical components and connections than conventional combination photovoltaic systems. However, no solar thermal collection functionality is provided, and thus the building needs to consume more power to provide thermal comfort. Also, there is no warm or cool water collection capability.

US 5,505,788 discloses a photovoltaic roofing assembly which comprises a roofing membrane, a plurality of photovoltaic modules disposed as a layer on top of the roofing membrane, and a plurality of pre-formed spacers, pedestals or supports which are respectively disposed below the plurality of photovoltaic modules. This disclosure provides temperature regulation to the photovoltaic cells, and generates electrical power. However, the disclosure is restricted to building with roofing membrane, and it is not suitable for mounting on side wall.

GB 2365 116 discloses a hybrid photovoltaic/thermal system with pipes, solar tracking system integrated into one unit. A plurality of photovoltaic cells are attached to a metal substrate having a high thermal conductivity with means for cooling the said substrate and means for varying the orientation of the substrate to maximize the solar irradiance incident upon the photovoltaic cells. This disclosure could not be used as roofing material, and the thermal conductivity between the photovoltaic cells and the fluid is limited by the small contact surface between the substrate and the metal tube. There are further heat loss between the metal tube and the manifold that carries the fluid.

GB 2446219 discloses a hybrid photovoltaic and solar heat collector panel. One or more thin film photovoltaic cells are deposited onto a metal plate, to which metal pipes or metal fins are attached for heat transfer to circulating fluid. This disclosure is good when air is used as the heat transfer medium to cool the metal fins. However, when metal pipes that carry fluid are attached to the metal plate, the cooling of photovoltaic cells is limited by the small contact surface between the pipes and the metal plate.

Summary of Invention

A primary object of this invention is to provide a roof and wall system with multiple functions that include shielding a building from the elements, generating electricity, collecting and regulating thermal energy concurrently.

Another object of this invention is to provide dynamic thermal control to regulate the building interior temperature so as to reduce the heating and cooling energy consumption.

Another object of the invention is to provide a modular multiple functional roof and wall system to meet different building design.

The present invention also envisions a combination of a plurality of the multiple functional roof and wall system and a water heating/cooling system mounted on the building in a manner to collect solar heated water or fluid, or night sky cooled water or fluid, and provide building comfort that experiences daily temperature variations. It acts as a large active thermal mass on the roof and wall, regulates the daily temperature fluctuation, and reduces the energy consumption of the building. Plumbing components such as pipes, joints, pumps, valves are connected to the roof system so as to enable the flow of fluid or fluid with additives in the hollow channels of the multiple functional roof and wall system. The combined system is driven by a smart controller, which dynamically controls the building thermal insulation. The fluid subsequently releases or absorbs the heat from a water or fluid storage system. Either warm or cool water are collected by respective storage tanks for further uses.

In the daytime, the invention collects warm water, cools the roof and wall, and provides space cooling within the building. It also improves the photovoltaic power yield as it cools down the operating temperature of the Photovoltaic cells.

In the night time, the invention collects water or fluid cooled by radiation to the night sky. It once again improves the building thermal insulation as warm water or fluid collected in the daytime is circulated back to the multiple functional roof and wall system, and therefore reducing the heat loss from the inside to the outside. In certain hot and humid tropical areas, where night temperature remains elevated, the building, especially those built with large thermal mass materials, will retain the excessive solar heat absorbed in the day time, and re-radiate them back into the night sky at a very slow rate. The invention cools the building by pumping water from a separate cool water tank through the multiple functional roof and wall system and provides building thermal comfort.

These objectives are achieved by ways of modular Thermally Controlled Roof and Wall profile, known as TCRW profile. The TCRW profile is a metallic profile each with a flat surface on the top side and hollow channel on the underside. The hollow channel is preferred to have a large contact surface with the top side to allow for optimum heat transfer between the topside and the medium that flows in the hollow channel. It is preferred that the TCRW profile is aluminum extrusion which is a matured and cost

effective fabrication process that can produce very long section in excess of 6m. It is important to note that the top surface and the hollow channel is an integrated piece of metal and hence there is no interfacing heat conducting loss. In area with temperate climate, it is preferred that the inner or the bottom side of the TCRW profile be coated with good thermal insulation paint to retard heat dissipation into the building during daytime, and reduces heat loss in the night time.

It is further provided that the modular TCRW profile has interlocking features on the sides so that two adjacent TCRW profiles can be joined together seamlessly. Sealants or adhesives are further applied to the joints to achieve water tightness. Additional features of TCRW profile includes ease of mounting on the building supporting structure.

Depending on the size of the roof or wall, plurality of the TCRW profiles are interlocked together to form a large flat roof surface that is water tight. Photovoltaic laminates are then adhered to the top surface of the roof for converting sun irradiance to electrical energy. Flexible photovoltaic laminates such as amorphous silicon PV laminates from Unisolar, or copper indium gallium di-selenide (CIGS) based thin-film PV modules from Ascent Solar or Global Solar are readily applicable. Suitable inverters and electrical protection circuits are then connected so that the photovoltaic system can supply electricity to the utility grid or to a standalone system.

Depending on the user's need, the multiple roof and wall system could be operated based on optimum water and/or space heating or cooling, maximum solar energy cogeneration, or user settable priority to suit their needs.

Drawings Description

Fig. 1 Perspective view of a multiple functional roof and wall system mounted on a building

Fig. 2 Cross section view of the TCRW profile

Fig. 3 Cross section view of a plurality of TCRW profiles joined together to form a flat surface

Fig. 4 Schematic view of a TCRW profile with manifolds for fluid inlet and outlet

Fig. 5 Schematic view of a TCRW panel with amorphous silicon PV laminate attached

Fig. 6 Schematic view of a TCRW panel with crystalline PV-cells attached

Fig. 7 Schematic view of a TCRW panel with side weather blocking profiles for barrel roof tiles cladding

Fig. 8 Illustrate the cladding of a TCRW panel with barrel roof tiles

Fig. 9 Schematic view of a row of TCRW panels with side weather blocking profiles

Fig. 10 Schematic view of 4 TCRW panels mounted on battens and rafters

Fig. 11 Side view of a house with multiple functional roof and wall system, with TCRW panels mounted on the roof, integrated with water heating and storage system. The potable water is supplied to the kitchen, bathroom and toilet

Fig. 12 Schematic view of a TCRW panels interfacing to an inverter, and subsequently to the grid line

Fig. 13 Illustrates an entire multi-functional roof and wall system integrated with TCRW panels, solar water heating system, and inverter system.

Fig. 14 Illustrates an entire multi-functional roof and wall system integrated with TCRW panels, solar water heating system with drain-back reservoir tank, and inverter system.

Fig. 15 Illustrates an entire multi-functional roof and wall system integrated with TCRW panels, solar water heating and cooling system.

Fig. 16 Shows the flow chart of a multiple functional roof and wall system, which collects warm water in the daytime, and provides human thermal comfort in the night time.

Description of the Invention

A multiple functional roof and wall system pursuant to the current invention to provide cogeneration of solar energy through solar thermal absorption and photovoltaic means, and also provides thermal comfort to the building. The system comprises of a plurality of TCRW profiles 20 which are joined together side by side, 22 and 23, to form a largely flat watertight surface 21, and a layer of photovoltaic cells that are attached to the outer layer of the TCRW profiles 20. The multiple functional roof and wall system can be used on any building which include, but not limited to, commercial building, residential house, apartment, garage, or any type of building. For the purpose of illustration and not limitation, a plurality of such multiple functional roof and wall system can be mounted on a roof and/or wall on a building for electricity generation, water heating or cooling, and acts as a large active thermal mass to provide building comfort and energy reduction. The embodiment fits nicely into a passive solar building or green building, and provides flexibility in the building design. As an illustration, the distribution of heat within the building during night time is achieved easily by the circulatory system of the invention, and thus the placement of rooms poses less constraint to the building designer.

In regions with arid climates, the heat from the hot sun in the day time is absorbed by the TCRW panels 11 installed on the roof and wall, and get transferred to a fluid storage tank. The invention acts to retard the heat flow from the exterior to the interior, and thus the space within the building remains cool. At the same time the invention converts the solar energy into electrical energy for self consumption and for supply to the grid or later use. The cooling of the TCRW panel 11 also results in lower PV cell operating temperature, and thus a higher energy yield is obtained since PV cell has a negative power temperature coefficient. In the night time, when the temperature falls drastically, the large thermal mass of the fluid used by the invention slows the loss of heat from within the building to the exterior world. The heat energy absorbed in the day time is circulated through the multiple functional roof and wall system, and re-radiate into the building keeping the interior space warm.

In temperate region where the daily temperature fluctuation is less drastic than arid climates, the invention provides better thermal insulation, and thus better thermal comfort within the building. The invention could also be used as a collector for a seasonal thermal store, where a large thermal store is warmed by the heat from the TCRW panels 11 and deposited during the hot summer months. The thermal store is then used to warm the space within the building in the winter weather via the same TCRW panels 11.

In hot and humid tropical climates, as usual the multiple functional roof and wall system absorbs the solar irradiance and stores the heat in a storage system during daytime. However, the night temperature in these areas remains elevated, and any use of the absorbed heat in the night time will only increase the temperature within the building further. In another embodiment of the current invention, a separate fluid storage tank is integrated for cool fluid storage. The invention will shut off the warm fluid tank and activate the cool fluid tank. The circulation of the cool fluid through the multiple functional roof and wall system lowers the space temperature within the building, and thus provide human thermal comfort. Water from the utility is a good choice as a cooling fluid.

Due to the harsh outdoor environment, the component used to collect solar thermal or generate electricity has to resist degradation problem caused by ultra-violet ray, absorb the impact from the hailstones, subject to thermal shock, and retard corrosion. In the case of PV module, the crystalline silicon PV cells are encapsulated using a laminating process. The PV cells are sandwiched between two layers of Ethylene-Vinyl Acetate (EVA in short), with a top protective transparent cover, mostly tempered glass, and a layer of composite backsheet on the bottom side. The entire laid up assembly is then vacuum and thermally bonded together by a lamination machine. The laminated PV cells can be adhesively bonded to the TCRW profile by another layer of EVA between the bottom side of the laminated PV cells and the top side of the TCRW profile. In a preferred embodiment of the present invention, the usual composite backsheet is replaced by the TCRW profile and the entire laid up assembly is laminated together by the lamination machine. In doing so, the thermal conductivity between the PV cells and the TCRW profile is better than one with the composite backsheet.

Figure 1, shows a building 18, such as a factory or office. In this example, the building is installed with TCRW panels 11 on the roof 8 and 9, and wall 7. The TCRW panels 11 on the roof 9 and the wall 7 were adhesively bonded with crystalline silicon PV cells. Crystalline silicon PV cell have efficiency of up to 23%, and is a good choice for electrical power generation when the roof or wall space is limited. The TCRW panel 10 on the roof 8 is adhesively bonded with amorphous silicon PV laminates. These PV laminates are flexible and easy to install on the roof. On large scale production, these laminates have achieved efficiency of 9-10% range, and possibly 2-3% more in near future. Regardless of the types of PV cell used, the roof and wall surface integrated with PV cells allows a very viable material choice for green building. Current invention serves this function, with the further ability to collect warm or cool fluid for building thermal comfort and energy reduction.

Figure 2 shows the cross-sectional view of a TCRW profile 20 of the current invention. The TCRW profile 20 is preferably extruded using aluminum, or more commonly aluminum alloy, although in other embodiments, other metal extrusion or choice of metal can be used. The TCRW profile 20 has a flat surface 21 wherein it is mounted facing outwards to receive solar irradiance in the day time. Multiple TCRW profiles 20 are joined together by side frames 22 and 23 to form a large roof or wall surface, and this is illustrated in Figure 3. The side frames 22 and 23 of adjacent modules are sealed together using sealants to form a water tight surface. The design of frames 22 and 23 prevents water from flowing to the lower or inner portion of TCRW profile 20, which alleviate the possibility of water seeping through the roof and wall system should wear and tear or external unintended force causes the sealants to degrade or crack. The TCRW profile 20 has a hollow section 26, wherein fluids flows through for heat exchange by either natural or forced convection. Either air or water could be used as the fluid to transfer heat away from the TCRW profile 20. To ensure fast heat transfer, the hollow section 26 has a large contact surface with the fluid within it. The surface area of hollow section 26 is further increased by fins 24. Effectively, the TCRW profile 20 acts as large heat sink in the day time to bring the solar heat energy to a fluid storage tank 50, and keep there for later use. Both ends of the hollow section 26 are fitted with manifolds 100 and 101 as shown in Figure 4. Fluid is brought into the TCRW profile 20 via the fluid inlet 110 of the manifold 100, and brought out of the TCRW profile 20 via fluid outlet 111 of the manifold 101.

In places where the night temperature drops below human comfort zone, it is preferred that the inner side or the side of the TCRW profile 20 that faces the building interior be coated with good thermal insulation paint to retard heat conduction between the TCRW profile 20 and the space within the building. As an illustration, but not limitation, the thermal insulation paint utilizes ceramic micro-spheres technology, originally developed by NASA, which when dried form a solid film of ceramic particles on the TCRW profile 20, thereby trapping the solar heat within the TCRW profile 20 during daytime for fluid convection, reducing the building interior heat energy lost during night time, and thus enhances building thermal comfort.

The C-shaped grooves 27 and 28 are integrally formed next to the side frame 22 and 23. It allows mounting of the TCRW profile 20 to the roof structure, such as battens 30 as shown in Figure 10, by screw fixing securing elements of corresponding shape.

Figure 5 shows the TCRW profile 20 with flexible amorphous silicon PV laminates, or flexible CIGS based thin-film PV laminate, sealed to the upper layer 21. The thin-film amorphous silicon PV flexible laminate which typically uses ethylene propylene copolymer adhesive-sealant with microbial inhibitor, is flexible, lightweight and exceptionally durable due to ethylene tetrafluoroethylene (ETFE) polymer encapsulation. The use of ETFE as PV laminates top cover allows fast and easy installation on the roof. The low cost amorphous silicon PV cell 15 achieves close to 6 to 13% efficiency with triple-junction cell approach. The PV laminate usually comes with rectangular shape, with length variation up to few meters between models and manufacturers. The current invention uses extrusion technology to fabricate the TCRW profile 20, and thus allows

flexibility in final system dimension. Customized roof and wall system sizes are easily accommodated.

The PV laminate generates electrical power under sunlight. The heat generated by the PV cells, and the solar radiation that passes through or between the cells, are transferred to the flat surface 21 of the TCRW profile 20 below. The heated TCRW profile 20 is then cooled by the fluid within the hollow section 26, which are brought in via fluid inlet 110 of manifold 100, and out via fluid outlet 111 of manifold 101 as shown in Figure 4.

Figure 6 shows another embodiment, with crystalline silicon PV cells attached to a plurality of the TCRW profile 20. Crystalline silicon PV cells are usually protected by a tempered solar glass, and encapsulated by EVA. In this example, which serves as an illustration and not limitation, the TCRW profile 20 has a width that matches the crystalline silicon PV cell size found in the market, allowing ease of cell layout, optimization of space and materials, and optimum heat transfer to TCRW profile 20. The illustration showed twenty crystalline PV cells attached to the watertight flat surface formed by 4 TCRW profiles 20, and formed a TCRW panel 11 when encapsulated by EVA and protected by tempered glass or other inert transparent material, such as ETFE or PTFE. In this embodiment, the TCRW profile 20 is electrically insulated from the PV cells by an anodized oxide layer of thickness 15-30 μm . Other insulation method, such as powder coating of sufficient thickness could be used. Similar manifold 100 and 101 can be used to bring fluid in and out of the hollow section 26 at designated rate for desired heat transfer. The cells are electrically connected in series, and connected to a junction box or a pair of PV cables for further connection to other similar embodiment.

Figure 7 shows another embodiment of the current invention. Two weather blocking metal profiles 210 and 211 are sealed to a TCRW panel 11. In this illustration, the profiles 210 and 211 are shaped to interlock with barrel roof tile 220 shown in figure 8. The interface between the embodiment and the roof tiles become straight forward, and no sealing is needed between them. The embodiment now serves three functions - as a solar thermal collector, an electrical power generator, and also as a roofing material. The shapes of profiles 210 and 211 could be altered to allow interlocking of the embodiment with other types of tiles found on the market.

Figure 9 shows the similar embodiment, but with a plurality of TCRW panels 11 joined together to form a row of energy harnessing roof surface. Only one pair of weather blocking profiles, 210 and 211, is needed in each row. Depending on the roof space available, multiple rows of collectors can be mounted to generate more electrical energy, and/or heat a larger amount of water for bigger community of users. This is shown in Figure 1. In Figure 10, four TCRW panels 11 are arranged in a 2 by 2 matrix which form a TCRW array 38, are mounted and secured on the equally spaced battens 30. The battens are in turn rested and secured to the rafters 31 below.

With the embodiments mentioned above, the TCRW panel 11, with either amorphous silicon, crystalline or other thin-film PV cells attached to the flat surface 21, could be mounted on the roofs with minimal effort and time to form a large energy harnessing

watertight surface, and reduces the materials needed for roof structure. Similar method can be used to mount the current invention on wall or façade.

Once the TCRW panels 11 are mounted on the roof and/or wall, they will be electrically connected either in series and/or parallel, depending on the inverter or battery charger used. The voltage generated, and the open circuit voltage of the PV string, have to match the specification of the inverter or charger. In figure 12, an inverter 80 is used to convert the DC power of the TCRW array 38 to AC power. It is then fed to the grid line 82.

For the purpose of illustration, and not limitation, figure 13 shows a system that co-generates electrical and thermal energy using the current invention. Fluid, which can be water or air, is circulated through the TCRW array 38 via cool fluid pipe 52 and hot fluid pipe 53. During the day time, the TCRW profile 20 is heated by the solar irradiance and the PV cells. The rise in the temperature of the cell reduces cell performance, and the solar energy harnessing efficiency is decreased. To solve the problem, the TCRW profile 20, and thus the PV cell, is cooled by the fluid within the hollow section 26. In this illustration, the fluid is circulated within the pipes 52 and 53, and the TCRW array 38 by natural convection. The heated fluid rises and flow out of the TCRW array 38 via hot fluid pipe 53, and forces cooler fluid to flow in via cool fluid pipe 52. The heated fluid flows to the heat exchanger 55 and is cooled by the water within the exchanger. The water is supplied by the water tank 50 which receives cool water from the pipe 51. As the water flows through the exchanger 55, it absorbs the heat from the heated fluid, gets warm, flows back to the water tank 50, and get stored there. The warm water is then used via pipe 54. In the illustration, the heat exchanger 55 is indicated as a standalone component. In many practical systems, the heat exchanger is part of the water storage tank system. All control valves are intentionally left out to simplify the illustration.

The electrical power generated by the TCRW array 38 is directed to the inverter 80 for AC conversion. Any good quality grid-tied inverter can be used for this purpose. The AC output is then connected to the control panel 81, where it is fed to the grid.

The circulation rate of fluid by nature convection may not be fast enough, and renders the system inefficient. In figure 15, a collector loop pump 58 is introduced and placed at cool fluid pipe 52 to increase the flow rate of the fluid. In this way, the system is able to conduct heat away from the TCRW array 38 much quicker, cools the PV cells faster to harness more solar energy, and improves the system efficiency. The gain in harnessed energy will be higher than energy consumed by the pump. Either DC or AC pump could be used, but AC pump will be useless when there is power outage.

In cold country, or places where night temperature drops below water freezing point, freeze protection is needed to prevent the fluid from changing to solid state and breaks the pipe 52 and 53. In figure 14, a drain back reservoir tank 57 is added to the collector loop at pipe 53. The fluid, mainly distilled water, in the TCRW array 38 and the exposed pipe 53 is drained into the drain-back reservoir tank each time the pump 58 is shut off. A sight glass attached to the drain-back tank shows when the reservoir tank is full and the

TCRW array 38 has been drained. When it is needed to circulate the distilled water through the collectors 38, the pump 58 is activated again.

Figure 11 shows a cross section view of a building, illustrating how the current invention is being used to collect warm water and used in the building. The building roof is clad with a plurality of the TCRW panels 10 or 11, which gets heated in the day time. The heat-transfer fluid in the pipe 52 and 53 circulates the loop and arrived at the heat exchanger 50 to release the heat energy back to the potable water within the heat exchanger. The warm potable water then goes to the user via pipes 54, and lead to kitchen, bathroom and toilet.

Figure 15 shows the embodiment which utilizes two fluid storage systems, one for warm water collection 50, and the other for cool water storage 59. For illustration purposes only, the system consists of two heat exchangers and two water tanks, 50 and 59, which operate separately. The control mechanism is illustrated by the flowchart in figure 16. When the controller 70 boots up, it will perform system initialization 500, and self diagnosis checks to verify the functionality of the sensors and other system components. Once ready, the controller 70 will check if it is now daytime or night time 501 to determine what mode of operation it should go into. During the daytime, the controller 70 will attempt to collect warm water and store them in storage tank 50. The controller achieves this by first measuring the TCRW 38 temperature 502 using the temperature sensor 91. Once the temperature 502 goes above certain threshold and if the collector pump 58 is not activated, the controller 70 turns on the collector pump 58 to bring the warm fluid at the TCRW array 38 to the heat exchanger 55 so that the heat can be released to the warm water loop and go into the warm water tank 50. Normally the TCRW array 38 is cooled by this mechanism, and the PV cell is working in an optimum operating temperature condition. If the user is not using the warm water, the warm water tank 50 starts to get warmer, the TCRW array 38 temperature will starts to rise again. In this case, the controller 70 will activate the cold water pump 61 so that some of the solar heat can be transferred away from the TCRW array 38 to the cold water tank 59. To mitigate warm water in cold water tank 59, it is preferred to size the solar water system appropriately, with a solar fraction of between 60-80%.

The mode of operation changes during night time, as TCRW array 38 cooling for optimal PV operation is not needed anymore. Depending on the climate, either warm water tank 50 or cool water tank 59 could be used in the night time to achieve human thermal comfort within the building. The controller 70 monitors the building interior temperature, and activates the warm water pump 56 and collector pump 58 if the building interior is too cold 510. The circulation of warm water to the heat exchanger 55 will warm the fluid in the collector loop, and subsequently warm the TCRW array 38. The heat from the TCRW array 38 is then dissipated back into the building. For conservation of heat energy, it is preferred that only certain rooms within the building be temperature regulated. This requires more controlling mechanisms and piping to bring the heat to designated areas only. If the building interior is too warm 512, the controller 70 will activate the cold water pump 61 and collector pump 58 so that the TCRW 38 array is cooled by the cold fluid.

Claims

1. A multiple functional roof and wall system comprises at least one TCRW profile preferably formed by aluminum alloy extrusion containing a flat top surface and a hollow channel beneath; laminated PV cells are adhesively bonded to the said flat top surface of the TCRW profile; a plurality of TCRW profiles are joined side by side to form large flat watertight surface of different dimensions to match the size of a roof or wall.
2. The multiple functional roof and wall system of claim 1 wherein fluid preferably water flows in the hollow channel of the TCRW profile and the said fluid has a large contact surface with the top side of the TCRW profile on which the laminated PV cells are attached.
3. A multiple functional roof and wall system of claim 2 wherein the TCRW profile is anodized or coated with materials with good thermal conductivity and good electrical insulation on its surface and in particular the top surface where the laminated PV cells are attached.
4. The multiple functional roof and wall system of claim 3 wherein the TCRW profile is modular and is joined with other TCRW profile side by side, and thus allowing variation of the width of the assembled system to match the roof or wall size.
5. The multiple functional roof and wall system of claim 4 wherein the extruded TCRW profile can be cut to the desired length.
6. The multiple functional roof and wall system of claim 5 wherein the TCRW profiles are joined together to form a watertight roof or wall surface with features on the underside to mount onto standard building structures.
7. The multiple functional roof and wall system of claim 6 wherein manifolds that bring in and bring out the fluid to the hollow channel are installed at both ends of the TCRW profiles.
8. The multiple functional roof and wall system of claim 7 wherein laminated PV cells of either crystalline silicon or thin-film materials are adhesively bonded to the top surface of the TCRW profiles to form TCRW panels.
9. The multiple functional roof and wall system of claim 8 wherein laminated PV cells are made from crystalline silicon with proper interconnection and encapsulation and an outer protective layer, such as low iron tempered glass, is adhesively bonded to the top surface of the TCRW profile to form crystalline silicon TCRW panel.

10. The multiple functional roof and wall system of claim 9 wherein ethylene-vinyl acetate or equivalent is used to adhesively bond the entire PV cells assembly and the top protective layer onto the TCRW using thermal vacuum lamination technique.
11. The multiple functional roof and wall system of claim 8 wherein thin-film PV laminate or amorphous silicon PV laminate, is adhesively bonded to the TCRW profile to form a thin-film TCRW panel.
12. The multiple functional roof and wall system as claimed in claim 8 comprises at least one fluid storage tank with heat exchanger to heat or cool the fluid in the tank; piping that directs fluid from the heat exchanger to the inlet of the TCRW panels and allows fluid to flow back to the heat exchanger from the outlet of the TCRW panels; a controller that monitors the temperature of the TCRW panel and the temperature of the fluid tank, and to operate pumps to circulate the fluid through the entire system and safety mechanisms to prevent system failure.
13. The multiple functional roof and wall system is a method to concurrently convert solar irradiance into electrical energy, heats up the fluid within the TCRW panel during the day and cools down the fluid during the night and to regulate the interior space temperature by circulating either warm or cool water through the TCRW panels;
14. The multiple functional roof and wall system method as claimed in claim 13 multiple TCRW panels are electrically connected to generate electricity and thermally connected by pipes for fluid flow for heating and cooling.
15. The multiple functional roof and wall system method as claimed in claim 14 wherein the controller can be set according to the user requirement to achieve either interior thermal comfort or harnessing maximum solar energy.
16. The multiple functional roof and wall system method as claimed in claim 15 wherein the controller is able to differentiate between day and night.
17. The multiple functional roof and wall system method as claimed in claim 16 wherein the controller detects night time and activates the warm water pump to circulate warm water from the warm water storage tank to flow through the TCRW panels when the building interior temperature is lower than the set point.
18. The multiple functional roof and wall system method as claimed in claim 16 wherein the controller detects night time and activates the cool water pump to circulate the cool water from the cool water storage tank to flow through the TCRW panels when the building interior temperature is higher than the user set point.