

SUPPORTING STRUCTURE FOR GREEN BUILDING FACADE

FIELD OF INVENTION

The invention relates to supporting structures for green building facades.

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BACKGROUND TO THE INVENTION

The following discussion of the background to the invention is intended to facilitate an understanding of the present invention. However, it should be appreciated that the discussion is not an acknowledgment or admission that any of
10 the material referred to was published, known or part of the common general knowledge in any jurisdiction as at the priority date of the application.

Urban heat island effect (UHIE) refers to the phenomenon when city temperatures run higher than those in suburban and rural areas. UHIE occurs primarily due to the growing numbers of buildings being built as a consequence of
15 urbanization and economic growth, and these growing numbers of buildings have supplanted vegetation and trees previously filling the city area. In addition, human activities generate heat and such generation of heat contributes to the rise in city temperatures.

The city environment is greatly influenced by the higher temperatures. Firstly,
20 air quality in the city is lowered. The increase in temperature, together with the presence of air pollutants, results in the formation of smog, which not only damages the natural environment but also poses a danger to human health. Secondly, UHIE leads to greater use of electrical appliances such as fans and air-conditioning units, which directly affects the buildings' energy consumption.

25 In an attempt to reduce the adverse influence of the UHIE, vegetations are grown on rooftops (i.e. green roofs) and on building facades (i.e. green walls) to compensate for the loss of supplanted vegetation and trees. The vegetations serve to filter greenhouse gases such as carbon dioxide and other toxins in the city. It has been studied and demonstrated that such green roofs and green walls
30 help to reduce roof and wall ambient temperature and that heat transfer from the

roof and the wall to the rooms directly underneath the roof and behind the wall is lowered. A reduced ambient temperature and a lowered heat transfer from the roof and the wall to the rooms directly underneath the roof and behind the wall may result in lesser dependence on electrical appliances such as fans and air-conditioning units, thereby lessening the building's energy consumption.

As mentioned previously, an increase in surrounding temperature leads to greater use of electrical appliances such as fans and air-conditioning units, which in turn leads to greater reliance on fossil fuels for power generation. Although recently there have been developments and push for greener and renewable energy alternatives for power generation, such as solar, wind, hydroelectric and geothermal energies, to-date most nations still rely on depleting fossil fuels for power generation. In the process of burning the fossil fuels for power generation, greenhouse gases are produced and emitted into the atmosphere, thereby trapping more heat in the atmosphere and therefore more dependence on electrical appliances such as fans and air-conditioning units is needed. This creates a vicious circle which may be irreversible if more greenhouse gases are being produced and trapped in the atmosphere. In a further attempt to reduce the adverse influence of the UHIE, photovoltaic systems are employed in the buildings to reduce the reliance on fossil fuels.

Photovoltaics are solid-state, semi-conductor type devices that produce electricity when exposed to light. Photovoltaic materials (also termed as solar panels or solar cells) are increasingly being used to replace conventional building materials in parts of the building envelope such as the roof and the facades. They are increasingly being introduced into the construction of new buildings as a principal or ancillary source of electrical power, although existing buildings may be retrofitted with modules containing photovoltaic materials. Photovoltaic materials incorporated in the roof or facades of new buildings, or photovoltaic materials contained in modules for retrofitting in existing buildings are commonly known as building-integrated photovoltaics (BIPV). BIPV include all types of photovoltaic panels including hybrid photovoltaic panels. Briefly, during operation, sunlight shining onto the BIPV creates electricity. This electricity flows through power conversion equipment and into the building's electrical distribution system, feeding

electricity to the building's electrical loads such as air-conditioning and common lightings.

It is not until very recently the combined use of green roofs and BIPV in a single building has been proposed and tested out for its feasibility. The main advantages of this combination include easy installation and maintenance of the photovoltaic units, and higher efficiency of the photovoltaic units due to the cooling effect of the green roofs. The green roof cools ambient temperatures around the photovoltaic units, allowing the photovoltaic units to stay cooler and function better since it is well-known that cooler ambient temperature enhances the efficiency of the photovoltaic units.

Nevertheless, there are certain technical requirements to be met for the combined green roof and BIPV system. Firstly, the only types of vegetation that can be installed on the roofs with the photovoltaic units are the extensive types. Because most green roofs are on flat or gently-pitched roofs, photovoltaic units are typically mounted on supports to achieve optimal angle in relation to the sun. The photovoltaic units have to be installed above the vegetation level so that the photovoltaic units are not shaded by the extensive vegetation, thereby reducing its efficiency. On the other hand, the photovoltaic units provide partial shade for the vegetation during the day, thereby reducing evaporation rates and the amount of needed watering. At locations where strong winds are frequent, either an extremely strong metal structure and strong roof or a good wind block behind the photovoltaic units is needed, preferably both, in order to prevent wind damage.

It is desirable to provide a system for reducing UHIE that overcomes, or at least alleviates, the above problems.

SUMMARY OF THE INVENTION

Throughout this document, unless otherwise indicated to the contrary, the terms "comprising", "consisting of", and the like, are to be construed as non-exhaustive, or in other words, as meaning "including, but not limited to".

In a first aspect of the present invention, there is provided a supporting structure for mounting onto a building facade, comprising:

- a section covered with a photovoltaic system; and
- a section covered with a vegetation system.

BRIEF DESCRIPTION OF THE DRAWINGS

5 In the figures, which illustrate, by way of example only, embodiments of the present invention,

Figure 1 is an illustration of the supporting structure in a first aspect.

Figure 2a and **Figure 2b** show a rear elevation and a side elevation, respectively, of the supporting structure of **Figure 1** when mounted onto a building
10 facade.

Figure 3a and **Figure 3b** show partial view of the staircase core wall with the supporting structure after installation of the vegetation system, and after installation of the photovoltaic system and the vegetation system in a second aspect, respectively, in which the flooring between the vegetation system and the
15 photovoltaic system is sufficiently strong to withstand the weight of a man.

Figure 4a and **Figure 4b** show a perspective view and a side elevation, respectively, of a supporting structure in a third aspect where the vegetation system comprises concave and convex meshes.

Figure 5a and **Figure 5b** show perspective view and side elevation view,
20 respectively, of the supporting structure without the photovoltaic system in accordance with the first aspect where the vegetation system comprises convex mesh; **Figure 5c** and **Figure 5d** show perspective view and side elevation view, respectively, of the supporting structure with the photovoltaic system in accordance with the first aspect where the vegetation system comprises convex
25 mesh.

Figure 6a illustrates the positioning of the photovoltaic system and the vegetation system such that the gap between them is minimized; **Figure 6b**, **Figure 6c** and **Figure 6d** show the close-up views of a curved mesh in isometric view, side elevation view and plan view, respectively.

Figures 7a-e show alternative configurations of the mesh of the supporting structure.

DETAILED DESCRIPTION

5 The invention relates to supporting structures for green building facades.

In accordance with a first embodiment of the invention, there is provided a supporting structure **10** for mounting onto a building facade as shown in **Figure 1**. The supporting structure **10** comprises two sections: the first section is covered with a photovoltaic system **12** and the second section is covered with a vegetation system **14**. As illustrated, there may be a third section **16** which may be void or covered with other elements or systems such as glass panels, decorative panels and safety panels. The photovoltaic system **12** serves to generate electrical power from sunlight to reduce energy load of the building while the vegetation system **14** serves to cool the ambient temperature. The vegetation system **14** may also help to reduce surface temperature of the building facade.

The photovoltaic system comprises photovoltaic units such as solar panels. The photovoltaic units may be made up of individual photovoltaic sub-units joined together or a stand-alone photovoltaic unit. The photovoltaic units are secured to the supporting structure **10** by securing means such as bolts and nuts.

20 Alternatively, the photovoltaic units may be hooked onto the supporting structure **10**.

The vegetation system comprises a mesh for climber plants to cover the supporting structure **10**. Climber plants include, but not limited to, self-supporting plants such as root climbers and adhesive-suckers, and plants that need supporting structure such as twining vines, leaf-stem climbers, leaf climbers and scrambling plants. As the vegetation system will be exposed to the exterior, i.e. exposed to the harsh climatic conditions, hardy species and climbers with a tolerance for wind, heat, drought, frost, etc depending on the climatic conditions where the supporting structure is deployed should preferably be selected.

30 Preferably, the supporting structure **10** is shaped to have a substantially rectangular block configuration with vertical frames and horizontal frames forming

the skeletal. The first section covered with the photovoltaic system **12** is positioned on a first face of the supporting structure **10** whereby the first face of the supporting structure **10** is positioned further away from the building wall when the supporting structure **10** is mounted onto the building facade. The second section covered with the vegetation system **14** is positioned on a second face of the supporting structure **10** whereby the second face of the supporting structure **10** is positioned nearer to the building wall when the supporting structure **10** is mounted onto the building facade. In this arrangement, the supporting structure **10** serves to provide the following benefits: (i) the photovoltaic system **12** is not shaded or blocked by the vegetation and maximum exposure to sunshine may be achieved; (ii) some parts of the vegetation system **14** is shaded by the photovoltaic system **12** shielding the vegetation system **14** from harsh climatic conditions; (iii) the vegetation system **14** helps to cool the building facade and the surrounding ambient temperature, thereby reducing the energy load for the building as well as improving the efficiency of the photovoltaic system **12** which works more efficiently under cooler environments; and (iv) the outer photovoltaic system **12** is protected by the inner vegetation system **14** against vandalism, theft and damage since the photovoltaic system **12** is positioned further away from the building walls. In addition to the mesh, other protecting means for the photovoltaic system **12**, such as billboards and sign boards, may also be used. When both the mesh and billboards or sign boards are being used, the mesh may also protect the billboards or sign boards if the billboards or sign boards are installed in front of the mesh. Other shapes of the mesh are also possible, including irregular shapes so long as the mesh protects the photovoltaic system **12** from the top and behind.

Figure 2a and **Figure 2b** show a rear elevation and a side elevation, respectively, of the supporting structure **10** when it is mounted onto a building facade. In this embodiment, the supporting structure **10** is shown to comprise the first section covered with the photovoltaic system **12** being in a spaced apart relationship with the second section covered with the vegetation system **14**. As illustrated in **Figure 3a** and **Figure 3b**, the spacing between the photovoltaic system **12** and the vegetation system **14** may be fitted with flooring strong enough to support and withstand the weight of at least one man for the purposes of maintenance of the photovoltaic system **12** or vegetation system **14**, and watering

of the vegetation. **Figure 3a** shows partial view of the supporting structure **10** after installation of the vegetation system **14** and **Figure 3b** shows partial view of the supporting structure **10** after installation of the photovoltaic system **12** and the vegetation system **14**.

5 **Figure 4a** and **Figure 4b** show another embodiment of the supporting structure **10** in a perspective view and a side elevation view, respectively. In this embodiment, both the photovoltaic system **12** and the vegetation system **14** are positioned on the first face of the supporting structure **10** whereby the first face of the supporting structure **10** is positioned further away from the building wall when
10 mounted onto the building facade. The photovoltaic system **12** is placed in a spaced apart relationship with the vegetation system **14** and the vegetation system **14** is placed nearer to the building wall than the photovoltaic system **12**. The mesh of the vegetation system **14**, in this embodiment, is shown to be shaped in a curved configuration instead of a flat plane (as illustrated in **Figure 2**) when
15 viewed from the side elevation. The vegetation system **14** is shown to consist of meshes having concave configuration and convex configuration. The photovoltaic system **12** is positioned in front of the concave mesh of the vegetation system **14** so that the convex mesh of the vegetation system **14** is substantially flush with the photovoltaic system **12**. With the flushing of the vegetation system **14** with the
20 photovoltaic system **12**, a person who throws things over the parapet wall of the building façade would not damage the photovoltaic system **12** from the top.

In a third embodiment, **Figure 5a** shows the perspective view and **Figure 5b** shows the side elevation of the supporting structure **10** comprising only the vegetation system **14**. **Figure 5c** shows the perspective view and **Figure 5d**
25 shows the side elevation of the supporting structure **10** comprising the vegetation system **14** and the photovoltaic system **12**. **Figures 5a-d** show clearly the curved mesh of the vegetation system **14** having a convex configuration whereby the mesh is bulging outwardly. The edges of the mesh curve inwardly in order to accommodate the photovoltaic system **12** as shown in **Figures 5c-d**.

30 In a close-up view of the curved configuration of mesh of the vegetation system **14** shown in **Figure 6a**, the spaced apart relationship, i.e. gap, between the photovoltaic panels **12** and the mesh of the vegetation system **14** is minimized so

as to effectively reduce the heat built-up at the rear of the photovoltaic panels. Vegetation placed behind the photovoltaic panels would cool the ambient temperature surrounding the photovoltaic panels. Therefore, the closer the vegetation are placed to the photovoltaic panels, the cooler the ambient

5 temperature surrounding the photovoltaic panels and hence improved efficiency of the photovoltaic panels. The mesh may be designed such that the gap between the mesh and the photovoltaic panel is not too wide resulting in an angle too steep for climber plants to grow. At the same time, the angle of the mesh has to be sufficient to allow (i) spacing between the mesh and the photovoltaic system so

10 that during operation, the individual performance of the vegetation system and the photovoltaic system is not affected by the other and (ii) to allow access to the photovoltaic panels for maintenance. The mesh may be bent in such a way that the vegetation system is flush with the photovoltaic panels without shadowing the photovoltaic panels and yet protects the photovoltaic panels and/or billboards and

15 sign boards from damage caused by litter thrown from the top of the building as well as protects the photovoltaic panels from damage from the rear of the photovoltaic panels. The mesh is designed to have minimal length of cantilever beams from the facade so as to minimize structural loading and sizing of structural members. **Figures 6b-d** show close-up views of the curved mesh in isometric,

20 side elevation and plan views, respectively. Other configurations of the mesh arrangement and the angles of curved mesh of the vegetation system **14** are also possible. Further examples of such mesh arrangement, such as straight, wavy, pyramidal, curved and bent are illustrated in **Figures 7a-e**.

The advantage of BIPV over more common non-integrated systems is that the

25 initial cost can be offset by reducing the amount spent on building materials and labor that would normally be used to construct the part of the building that the BIPV modules replace. In addition, since BIPV are an integral part of the design, they generally blend in better and are more aesthetically appealing than other solar options. These advantages make BIPV one of the fastest growing segments

30 of the photovoltaic industry.

Besides the well-established benefits of reducing UHIE and therefore reduced energy consumption and improved air quality, cities are now cooler and quieter through the shading, evaporative transpiration and the absorption of sound by the

green facades. Green facades can also help to reduce surface runoff from the buildings.

The combination of a green building facade and photovoltaic system has advantages over the combination of a green roof and photovoltaic system.

5 Facades of buildings provide larger surface areas for mounting photovoltaic systems and vegetation systems as compared to the roofs of the buildings.

Therefore, cooler ambient temperatures and lower energy loads of the buildings may be achieved. Additionally, the roofs of the buildings generally experience harsher climatic conditions than the facades of buildings. Thus, the photovoltaic

10 systems and vegetation systems mounted onto building facades are more durable and stable. The outlook of the buildings are also generally more aesthetic and pleasant looking due to the greenery provided by the vegetation systems spanning over larger surface areas of the facades. Without the vegetation system and the photovoltaic system mounted onto the facades, glare or reflection of the sunlight
15 from the concrete facades may cause discomfort to the eyes. Greenery on the roofs may not have such effects since the roofs are generally less accessible and less viewable.

The supporting structure for the green building facade and the mesh of the vegetation system may be formed of lightweight materials (such as, but not limited

20 to, hot dipped galvanized mesh) that is resistant to corrosion and can withstand harsh climatic conditions. The supporting structure, including the mesh, may be modular and pre-fabricated to allow easy manufacture, installation and maintenance. Alternatives may include stainless steel cables, ropes, wires and rods. The supporting structures may be mounted onto the building facades by
25 securing means such as bolts and nut, hooks, etc.

Although the foregoing invention has been described in some detail by way of illustration and example, and with regard to one or more embodiments, for the purposes of clarity of understanding, it is readily apparent to those of ordinary skill in the art in light of the teachings of this invention that certain changes, variations
30 and modifications may be made thereto without departing from the spirit or scope of the invention as described in the appended claims.

I CLAIM:

1. A supporting structure for mounting onto a building facade, comprising:
 - a first section covered with a photovoltaic system; and
 - a second section covered with a vegetation system.
- 5 2. The supporting structure of claim 1, wherein the supporting structure is formed of a rectangular skeletal having a plurality of vertical frames and a plurality of horizontal frames.
3. The supporting structure of claim 2, wherein the photovoltaic system comprises at least one solar panel secured onto the plurality of vertical frames
10 and/or horizontal frames.
4. The supporting structure of claim 2 or 3, wherein the vegetation system comprises at least one mesh for supporting climber plants, the mesh secured onto the plurality of vertical frames and/or horizontal frames.
5. The supporting structure of any one of claims 1 to 4, wherein the photovoltaic
15 system and the vegetation system are placed in a spaced apart relationship, thereby forming a gap therebetween.
6. The supporting structure of claim 4, wherein the side-elevation configuration of the mesh is selected the list: straight, concave, convex, wavy, pyramidal, bent, and combination thereof.
- 20 7. The supporting structure of claim 6, wherein a first portion of the mesh is concave and a second portion of the mesh is convex.
8. The supporting structure of claim 7, wherein the photovoltaic system is secured at the concave portion of the mesh such that the photovoltaic system is flush with the convex portion of the mesh.

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