

A SYSTEM FOR GENERATING ELECTRICITY

Field of the Invention

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The present disclosure relates to a system for generating electricity and relates particularly, though not exclusively, to a system for generating electricity using solar cell modules and reducing transmission of infrared radiation.

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Background of the Invention

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Many buildings, such as greenhouses, airport terminals and the like have large glass panels through which sunlight penetrates and the infrared component of the sunlight often results in unwanted overheating of interior spaces. By reducing transmission of infrared radiation into the interior spaces such overheating can be reduced or even avoided. Such windows may have Low emission coatings ("Low-E coatings") to reduce the transmission of infrared radiation into the interior spaces.

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The present disclosure provides technological advancement.

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Summary of the Invention

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The present invention provides in a first aspect a system for generating electricity, the system comprising:

a first panel at least largely transmissive for light having a wavelength within a first wavelength range, the first panel being arranged to reflect a portion of the received light within a second wavelength range; and

a second panel positioned at an angular orientation relative to the first panel, the second panel including at least one solar cell module and being arranged to receive the light within the second wavelength range reflected from the first panel;

wherein the system is arranged such that at least one solar cell module to absorb at least a portion of the light within the second wavelength range to generate electricity.

The first and second panels may each be rotatable about respective axes.

Further, the system may comprise a frame and the first and second panels may be coupled to the frame such that the first and second panels are rotatable relative to the frame.

The system includes in one specific embodiment a drive arrangement coupled to the first and second panel and arranged to drive the first and second panels about respective axes.

The drive arrangement may be a manual drive, but typically includes an electric motor and may be arranged such that an angle between the first and second panel remains at least largely constant when both the first and second panels are rotated about their respective axes.

In one specific embodiment of the present invention the first wavelength range includes at least a portion of the wavelength range of visible light and the second wavelength range includes at least a portion of the wavelength range of infrared light. Further, the second wavelength range may also include at least a portion of the wavelength range of ultraviolet light.

The system for generating electricity may be mounted above or below an at least largely transparent panel of a building, such as a panel of a window structure or glass walls or roof structures of the building. For example, the window structure may form a part of a glasshouse for growing plants or any other structure that has large window panels (for example airport terminal buildings, train stations or the like), but may also form a part of a building or structure that has smaller window panels (such as a residential building).

In one embodiment the first panel has a reflective surface which forms an acute angle with a surface of the second panel, such as a light absorbing surface of the at least one solar cell module. The acute angle may be an angle between 10° - 80° , 20° - 70° , 30° - 60° or 40° - 50° and typically is an angle in the order of 45° . The second panel may at least largely obstruct the transmission of light having a wavelength in the visible and/or infrared wavelength range. The system for generating electricity may be arranged such that the drive arrangement can adjust a rotational position of the first and second panels by rotating the first and second panels about the respective axes whereby reflection of infrared radiation from the first panel to the second panel can be optimised and/or the second panel may at least partially form an obstruction for sun light thereby having a shading effect, which may be controlled by moving the first and second panels about the respective axes using the drive arrangement.

The system typically is in use positioned such that the axes of first and second panels are oriented at least approximately in an east-west orientation. The first and second panels may be elongated and may in use also be oriented in an east-west orientation. If solar light is received at a

direction perpendicular to the axes of the first and second panel (such as at midday), the incident infrared light will be reflected from the first panel to the second panel in a direction that is perpendicular to the axes of the first and second panels. Further, if solar radiation is received by the first panel at an acute or obtuse angle relative to the axes of the first and second panels (such as in the morning or in the afternoon), the infrared light will be reflected by the first panels to positions further along the second panels. Due to the east-west orientation and the elongation of the second panels, the reflected infrared light can consequently at least largely be received by the second panel regardless of daytime. It is consequently possible to optimise the reflection of infrared radiation and generation of electricity without the need for tracking the relative movement of the sun.

In order to optimise orientation of the first and second panels for different times during a year, the first and second panels can be rotated about the respective axes to a suitable north-south orientation angular orientation.

The present invention in accordance with embodiments has consequently the advantage that penetration of infrared radiation (heat radiation) into an interior of a building or structure can be controlled or limited and electricity can be generated using reflected infrared radiation. Further, shading can be controlled. In addition, if the system for generating electricity is positioned within a building or structure, such as below window panels of a greenhouse or airport terminal, the system for generating electricity is also protected from wind forces.

In a variation of the described embodiment the system for generating electricity may alternatively also be positioned

independent from, or in the absence of, a building or structure within open space, such as over growing plants.

In one embodiment the at least one solar cell module is
5 one of a plurality of solar cell modules, which may form an array.

Further, the first and second panels may form a unit and the system may comprise a plurality of units. The axes about
10 which the first and second panels of the units are moveable may be parallel to each other such that a louvre-type arrangement is formed. The units may be coupled such that the units can be driven by a single drive arrangement (such as an electric motor). Alternatively, each unit may comprise a
15 dedicated drive arrangement or groups of the units may comprise a dedicated drive arrangement.

The first panel typically has a reflective surface, which may be the surface of a coating that has a relatively high
20 reflectivity for infrared light, such as a low-emissivity coating ("Low-E coating"). For example, the Low E-coating may have a reflectivity greater than 70%, greater than 80%, greater than 90%, or greater than 95% of radiation within the Ultra-Violet (UV) and Near-Infra-Red (NIR) wavelength ranges
25 of 280 - 400nm, and 780 - 2000nm, or 780 - 2500nm. Further, the first panel may have an ultraviolet reflective coating.

The first panel may comprise a polymeric material such as polycarbonate, which may be largely transmissive for visible
30 light. The polycarbonate may be doped with dye or pigment materials. For example, the dye or pigment materials may be chosen such that visible light is filtered by the dye or pigment materials and transmission of light that is not beneficial for the growth of the plants is obstructed. The

inventor has observed that the growth of plants can be stimulated if light at selected wavelength bands within the visible light spectrum is obstructed from transmission to the plants and corresponding filtering of light consequently further facilitates the growth of plants if the system for generating electricity is for example used in a greenhouse application.

The at least one solar cell module may be of any type and may for example be a silicon-based or a thin-film-based solar cell module, a solar cell module based on polymeric materials, a solar cell module based on Perovskite materials or any other suitable type of solar cell module. In one specific embodiment the at least one solar cell module is selected to have a relatively high absorption efficiency in the infrared wavelength band, such as CIS or CIGS-based solar cell modules.

The system for generating electricity may also comprise a controller arranged to control operation of the drive arrangement to drive the first and second panels to a desired position such as a position in which generation of electricity is maximised (reflection of infrared radiation from the first panel to the solar cell modules of the second panel is maximised), or a desired intensity of visible light within a building or structure is achieved (controlled shading).

Further, the system for generating electricity may comprise a battery which in use is charged using electricity generated by the at least one solar cell module.

In addition, the system for generating electricity may comprise a light source, which may comprise LED light sources, such as LED light sources for emitting UV, blue, green, red, far-red and NIR light. A controller may be arranged to

operate the LED light sources during night time using electricity provided by the battery, which significantly facilitates growth of plants in case of use of the system for generating electricity for a greenhouse for example.

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The invention will be more fully understood from the following description of specific embodiments of the invention. The description is provided with reference to the accompanying drawings.

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Brief Description of the Drawings

Figure 1 is a schematic representation of a system for generating electricity in accordance with an embodiment of the present invention;

Figure 2(a), (b), (c) and 3 illustrate the function of components of the system for generating electricity in accordance with an embodiment of the present invention;

Figures 4 and 5 are further schematic representations of components of the system for generating electricity in accordance with an embodiment of the present invention; and

Figures 6 and 7 also illustrate the function of components of the system for generating electricity in accordance with an embodiment of the present invention.

Detailed Description of Embodiments

Referring initially to Figure 1, a system for generating electricity in accordance with an embodiment of the present invention is now described. The system 100 comprises first panels 102 and a second panels 104. The first panels 102 are largely transmissive for visible light and may for example

comprise a suitable polymeric material, such as polycarbonate. The first panels 102 further have a Low-E coating arranged to reflect incident infrared radiation. The second panels 104 have an array of solar cells and are positioned at an acute angle relative to the first panels 102. When the system 100 is used and sunlight is received by the first panels 102, visible light is transmitted through the first panels 102 (for example into an interior of a structure at which the system 100 is installed) and infrared light is reflected towards the second panels 104 where the solar cells receive the reflected infrared light and generate electricity.

The acute angle between the first panels 102 and the second panels 104 may be any suitable acute angle, but in one specific embodiment of the present invention is of the order of 45°.

The first panels 102 and the second panels 104 are supported by a frame 106 and are each rotatable about a respective axis. The axes of rotation of the first panels 102 and the second panels 104 are parallel to each other. In this embodiment the system 100 comprises a drive with electric motors arranged to drive the first panels 102 and the second panels 104 about the respective axes such that the acute angle between the first panels 102 and the second panels 104 remains approximately constant. The drive is controlled by a drive controller (not shown).

The second panels 104 are not transmissive for sunlight. By rotating the first panels 102 and the second panels 104 about the respective axes, it is consequently possible to control shading and/or optimise reflection of infrared radiation, which will be described below in further detail.

Figures 2 (a) to (c) illustrate the function of the system for generating electricity in further detail. Figures 2 (a) to (c) show a system 200, which corresponds to the system 100 shown in Figure 1. The system 200 comprises first panels 202 and second panels 204. The first panels 202 and the second panels 204 correspond to the first panels 102 and second panels 104, respectively, shown in Figure 1. Figure 2(a) shows the system 200 in a configuration in which the second panels 204 are oriented parallel to the direction of incident sunlight thus providing negligible shading. The first panels 102 allow transmission of visible light and the incident infrared light is reflected to the second panels 204 for generation of electricity.

Figure 2(b) shows the system 200 in a configuration in which the second panels 204 are oriented to effect partial shading (approximately 50%). The first panels 102 allow transmission of visible light and the incident infrared light is reflected to the second panels 204 for generation of electricity. Further, the second panels 204 also receive a portion of incident sunlight for generation of electricity. The first panels 202 and the second panels 204 are moved from the condition illustrated in Figure 2(a) to the condition illustrated in Figure 2(b) by rotating the panels about their respective axes in a manner such that an angular orientation of the first panels 202 relative to the second panels 204 remains unchanged.

Figure 2(c) shows the system 200 in a configuration in which the second panels 204 are oriented to effect more shading (approximately 80%). In this configuration the first panels 202 are oriented parallel to the direction of incident sunlight and consequently do not transmit (or is reflected) directly incident sunlight. The second panels 204 however are

oriented to receive a significant portion of the incident sunlight to generate electricity.

Figure 3 illustrates the first panels shown in Figures 1 and 2 in more detail and shows a cross-sectional representation of a first panel 300. The first panel 300 may replace the first panels 102 and 202 illustrated with reference to Figures 1 and 2. The first panel 300 comprises a body 302 formed from a lightweight polymeric material, in this case polycarbonate and has insulating and weight-reducing air pockets 304. The body 302 of the first panel 300 is largely transmissive for sunlight. Further, the first panel 300 has a Low-E coating 306. A person skilled in the art will appreciate that various types of Low-E coatings are available and be used for the panel 300. For example, the Low-E coating may have reflectivity greater than 90% for UV and infrared radiation within the wavelength ranges 280-400 nm and 800 - 2500nm. Further, the body 302 of the first panel 300 is in one embodiment doped with suitable pigments to filter incident sunlight such that preferentially only appropriate intensities of the blue, green, red and far-red radiations transmit through the first panel 300 and can reach the interior of a building or structure at which the system for generating electricity is in use positioned. This embodiment is particularly advantageous if the system for generating electricity is used in or at a greenhouse as the above-described filtering of the visible portion of the incident sunlight facilitates growth of plants. A second panel 308 is also schematically indicated in Figure 3. In summary, the first panel 300 transmits appropriate visible light spectral components and reflects infrared and ultraviolet light components towards the second panel.

Figure 4 schematically indicates a second panel 400. The second panel 400 may replace the second panels 104 and 204 illustrated above with reference to Figures 1 and 2. The second panel 400 comprises a body 402 formed from suitable polymeric material. Further, the second panel 400 comprises an array of solar cell modules 404. In this embodiment the solar cells are thin-film solar cells, which have a relatively high conversion efficiency in the infrared wavelength range. However, a person skilled in the art will appreciate that alternatively also other solar cells may be used. The solar cell modules 404 are in each row electrically series connected, but the rows of the solar cell modules 404 are then electrically parallel connected. If adjacent rows of the solar cell modules 404 receive different intensities of solar light, the generated electrical currents will also differ. By electrically parallel connecting the rows of solar cell modules 404, a negative impact on the total electrical current generated by the second panel 400 can be avoided and the total electrical current is the sum of the electrical currents generated by each row of solar cell modules 404.

Figure 5 shows a system for generating electricity 500 which comprises frame 502 provided in the form of structural members that may form a part of a roof frame structure. The system 500 comprises first panels 504 and second panels 506 supported by the frame 502. The first panels 504 and the second panels 506 may replace the first panels 102, 202 and the second panels 104, 204 illustrated with reference to Figures 1 and 2, respectively. The first panels 504 and the second panels 506 are rotatable about respective axes by a drive comprising electric motors 508 in a manner controlled by a controller (not shown).

Referring now to Figure 6, there is schematically shown a roof structure of a building into which the system for generating electricity is incorporated (not to scale). While in some embodiment the system for generating electricity may be positioned above a roof of a building or structure, it is in some embodiments preferred to position the system for generating electricity below (transparent) panels of a roof structure, such as a roof structure of a glasshouse, an airport terminal or another structure as then the system for generating electricity is protected from wind forces. The shown system 600 comprises a frame structure 602 which supports first panels 604 and second panels 606. The first panels 604 and the second panels 606 may replace the first panels 102, 202 and the second panels 104, 204 illustrated with reference to Figures 1 and 2, respectively. The first panels 604 and the second panels 606 are rotatable about respective axes by a drive comprising electric motors 608 in a manner controlled by a controller (also not shown).

Referring now to Figure 7, the function of the system 600 shown in Figure 6 is further described. Like components are given like reference numerals. The system 600 is positioned such that the first panels 604 and the second panels 606 are oriented in an east-west direction. As described above, the first panels 604 and the second panels 606 are elongated. As the sun moves relative to the system 600 during daytime, the angular orientation of the direction of incident sunlight changes relative to the axes of the first panels 604 and the second panels 606, but the relative orientation of the direction of sunlight in a transversal direction (north-south direction) remains constant. As a consequence, when for example the sunlight is received at grazing incidence in by the first panels 604 in a morning of a day, the infrared light is reflected by the first panels 604 to a position further

along the second panel 606, which is illustrated in Figure 7.
The reflection of the infrared light from the first panels 604
to the second panels 606 is consequently largely independent
from the time of the day and tracking of the sunlight is not

5 necessary.

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Claims

1. A system for generating electricity, the system comprising:

5 a first panel at least largely transmissive for light having a wavelength within a first wavelength range, the first panel being arranged to reflect a portion of the received light within a second wavelength range; and

a second panel positioned at an angular orientation
10 relative to the first panel, the second panel including at least one solar cell module and being arranged to receive the light within the second wavelength range reflected from the first panel;

wherein the system is arranged such that at least one
15 solar cell module to absorb at least a portion of the light within the second wavelength range to generate electricity.

2. The system of claim 1 wherein the first and second panels are rotatable about respective axes.

20 3. The system of claim 1 or 2 comprising a frame and wherein the first and second panels are coupled to the frame such that the first and second panels are rotatable relative to the frame.

25 4. The system of any one of the preceding claims comprising a drive arrangement coupled to the first and second panel and arranged to drive the first and second panels about respective axes.

30 5. The system of any one of the preceding claims wherein the first wavelength range includes at least a portion of the wavelength range of visible light and the second wavelength

range includes at least a portion of the wavelength range of infrared light.

6. The system of any one of the preceding claims wherein the
5 second wavelength range also includes at least a portion of the wavelength range of ultraviolet light.

7. The system of any one of the preceding claims wherein the
system is in use mounted below an at least largely transparent
10 panel of a building or structure.

8. The system of any one of the preceding claims wherein the
first panel has a reflective surface which forms an acute
angle with a surface of the second panel, such as an angle in
15 the order of 45°.

9. The system of any one of the preceding claims wherein the
second panel at least largely obstructs the transmission of
light having a wavelength in the visible and/or infrared
20 wavelength range.

10. The system of claim 9 wherein the drive arrangement is
arranged to adjust a rotational position of the first and
second panels by rotating the first and second panels about
25 the respective axes whereby reflection of infrared radiation from the first panel to the second panel can be optimised and/or the second panel may at least partially form an obstruction for sun light thereby having a shading effect.

30 11. The system of any one of the preceding claims wherein the system is in use positioned such that the axes of first and second panels are oriented at least approximately in an east-west orientation and wherein the first and second panels are elongated and also oriented in an east-west direction.

12. The system of any one of claim 1 to 5 wherein the system is in use positioned independent from, or in the absence of, a building or structure within open space, such as over growing plants.

13. The system of any one of the preceding claims wherein the at least one solar cell module is one of a plurality of solar cell modules, which form an array.

14. The system of any one of the preceding claims wherein the first and second panels form a unit and the system comprises a plurality of units, wherein the axes about which the first and second panels of the units are moveable are parallel to each other such that a louvre-type arrangement is formed.

15. The system of claim 14 wherein the units are coupled such that the units can be driven by a single drive arrangement

16. The system of claim 14 wherein each unit comprises a dedicated drive arrangement or groups of the units comprise a dedicated drive arrangement.

17. The system of any one of the preceding claims wherein the first panel has a low-emissivity coating ("Low-E coating").

18. The system of any one of the preceding claims wherein the first panel comprises a polymeric material which is largely transmissive for visible light.

19. The system of claim 18 wherein the polymeric material is doped with dye or pigment materials and wherein the dye or pigment materials are chosen such that visible light is filtered by the dye or pigment materials such that

transmission of at least some of the light that is not beneficial for the growth of the plants is obstructed.

20. The system of any one of the preceding claims wherein the
5 at least one solar cell module is selected to have a relatively high absorption efficiency in the infrared wavelength band, such as CIS or CIGS-based solar cell modules.

21. The system of any one of the preceding claims comprising
10 a controller arranged to control operation of the drive arrangement to drive the first and second panels to a desired position such as a position in which generation of electricity is maximised or a desired reduced intensity of visible light within a building or structure is achieved (shading).

15 22. The system of any one of the preceding claims comprising a battery which in use is charged using electricity generated by the at least one solar cell module.

20 23. The system of any one of the preceding claims comprising a light source, which comprises LED light sources, such as LED light sources for emitting UV, blue, green, red and far-red light.

25 24. The system of claim 24 when dependent on claim 22 comprising a controller arranged to operate the LED light sources during night time using electricity provided by the battery.