BACKGROUND

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Solar energy collection is understood to be desirable as a free energy source. Solar radiation is, however, diffuse (peaking at around just 1300 Watts per square meter) and arrives at ever changing angles and intensities. The collection of this solar energy is further complicated by its heterogeneous and changing mix of light wavelengths. Additionally, solar energy's various alternatives are very inexpensive, energy dense and well established in the market.

When electricity from the sun is desired, the photovoltaic (PV) effect of semiconductors is employed. Economies of scale have made photovoltaic panels containing Silicon cells cost competitive when compared to the most expensive electricity on the market (peak-hour retail watts.) However, solar electric generation is inhibited by the still relatively high cost and low net efficiency (a maximum theoretical of around 25%) of Silicon flat panel collectors. The expense of semiconductor materials and processing is understood to be key a challenge to the economic exploitation of the solar resource for electricity production.

At the high end of the performance efficiency range are multi junction photovoltaic cells that stack a variety of semiconductors, each of which transforms a different range of light-frequencies while allowing the rest to pass through. These multi junction cells are very expensive on a per square meter basis, fortunately they respond well to highly concentrated light (and some claim greater than 40% net efficiency under high concentration.)

At the other end of the expense range are thermal solar collectors that transduce the radiation of the majority of available light frequencies into sensible heat and direct that heat to either storage or immediately to some employment. This efficiency of transformation (greater than 80%) and, relative to photovoltaic conversion, low-cost, are the principal advantages of thermal collectors. The disadvantage for thermal approaches is that they must compete with a variety of inexpensive and energy dense fuel stocks such as natural gas and wood. Further, accomplishing high temperatures (and thus greater energy density and utility) requires more complex mechanisms and attendant higher costs.

Certain market and physical-technical forces have lead to the development of hybrid solar electric/heat systems also known as co-generation or PV-T (for photovoltaic-thermal.) By extracting both electricity and useable heat from a single collector's net aperture, the efficiency (energy captured as a percentage of the incoming sunlight) is increased. A common scheme is to mount the photovoltaic cells to a circulating coolant channel and drive the coolant through that channel to maintain a lower than otherwise accomplished temperature for the photovoltaic material. This increases the voltage and thus the watt-hour output. Additionally the harvested heat can be directed to some useful function. Heat is usually of lower economic value (watt-hour for watt-hour) so a higher electrical output is usually preferred, all other things being equal.

Known PV-T (or “hybrid collector systems”) can be usefully grouped into concentrating and flat plate collectors. The practice of allowing the radiation to enter the photovoltaic material full-spectrum and only afterward to remove the surplus, untransformed fraction of energy as heat is the same in both groups of collectors. Alternatively, it has been suggested that splitting the spectrum into diverse streams for exploitation by physically separate photovoltaic cells or uses would allow for somewhat less expensive (single or tandem junction) photovoltaic targets to be used. This would also reduce the need to scrub unconvertible energy. A key goal of these approaches is lowering the operating temperature for the photovoltaic components. The difficulty encountered here is the law of diminishing returns and each sub-assembly or surface employed brings with it production costs and energy losses. In addition the multi-junction cells remain expensive and so require high concentration collectors to be economically viable. In known high concentration collectors there is a concomitant waste of indirect light and a demand for greater heat management and more sophisticated sun tracking.

It is known that optical concentrator designers must choose between the higher maximum concentration ratios available to narrowly focused tracking systems (and in the process loosing the varied but considerable fraction of light that is not approximately collimated in the direct normal path from the sun's disk) or skipping the expense of tracking and trading maximized concentration for relative thrift in assembly and installation. The former are generally Cassegrain and Fresnel based concentrating collectors while the latter employ non-imaging optics often of the sort pioneered by Roland Winston and discussed in his book “Non Imaging Optics.”

There remains a need for maximized solar collection over a broad range of light conditions in an inexpensive device suitable for rooftop mounting. More particularly, there is a need for a solar collection apparatus that provides both high temperature heat relative to the ambient temperature and electricity. At the same time a low temperature work environment is desirable for the photovoltaic components of solar collection apparatuses. There is also a need for a hybrid PV-T system in which energy fractions that cannot be collected by photovoltaic means can be scavenged as heat and/or exhausted as inexpensively and decisively as possible so that it and the sun do not excessively magnify to the cooling load of the building below or degrade the performance of the photovoltaic components. Additionally there is a need for a hybrid solar collection system that can provide a variety of energy and service streams from the same system variously compatible with a building's energy needs and to reduce conversion losses.