The Environmental And Public Health Benefits of Achieving High Penetration of Solar Energy

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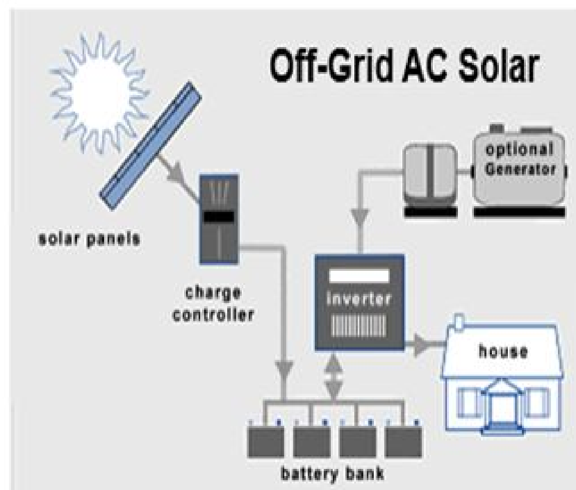
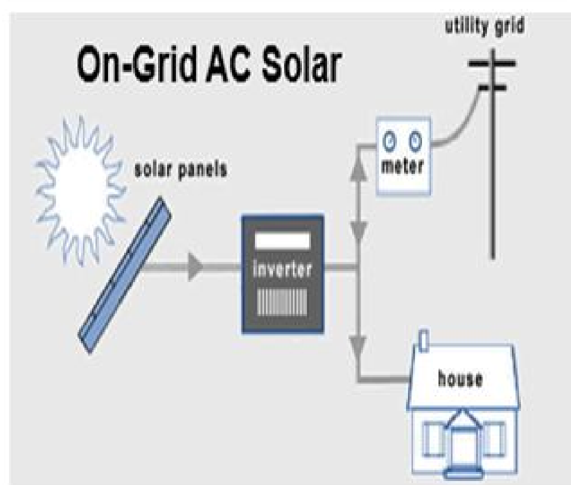
Abstract- *We estimate the environmental and public health benefits that may be realized if solar energy cost reductions continue until solar power is competitive across the U.S. without subsidies. Specifically, we model, from 2015 to 2050, solar power-induced reductions to greenhouse gas (GHG) emissions, air pollutant emissions, and water usage. To find the incremental benefits of new solar deployment, we compare the difference between two scenarios, one where solar costs have fallen such that solar supplies 14% of the nation's electricity by 2030 and 27% by 2050, and a baseline scenario in which no solar is added after 2014. We monetize benefits, where credible methods exist to do so. We find that under these scenarios, solar power reduces GHG and air pollutants by ~10%, from 2015 to 2050, providing a discounted present value of $56-$789 billion (central value of ~$250 billion, equivalent to ~2 cents/kWh-solar) in climate benefits and $77-$298 billion (central value of $167 billion, or ~1.4 cents/kWh-solar) in air quality and public health benefits. The ranges reflect uncertainty within the literature about the marginal impact of emissions of GHG and air pollutants. Solar power is also found to reduce water withdrawals and consumption by 4% and 9%, respectively, including in many drought-prone states.*

As an undergraduate researcher, I worked on a new technology called nanofluid-based direct absorption solar collectors (DASC) which is a type of solar water heater that has the potential to be more efficient than traditional solar water heaters. Some types of solar energy technologies that I wanted to focus on are photovoltaic solar energy systems, passive solar design,and solar water heaters. It is my opinion that tribes in all types of climates should consider using solar energy technologies as alternatives to traditional heating, cooling, electrical energy, and water heating methods because the technologies are mature, several tribes have some experience with them, and they are cost effective.

I. PHOTOVOLTAIC SOLAR ENERGY SYSTEMS

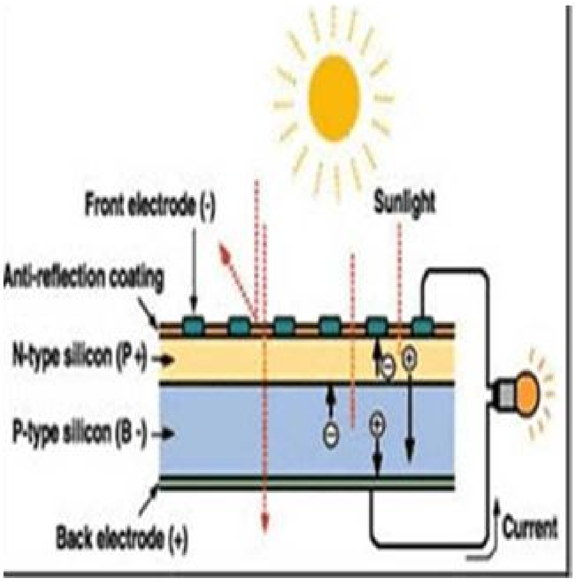
Photovoltaic (PV) solar energy systems absorb energy given off from solar rays and turn this energy into useable electric energy. PV systems consist of PV panels, an inverter to convert the direct current (DC) generated in the PV cells into alternating current(AC), energy storage, mounting structures for these panels and any accessory parts that the system at hand may require. If the system is going to be off the electrical grid, energy can be stored in the form of batteries will be required so that the system can operate during cloudy days or at night-time. If the system is going to be tied to an electrical grid, then a meter will be required. Battery storage could be added if the building requires power at all times, especially in the event of an emergency such as a natural disaster.





French physicist, Edmund Becquerel, first discovered the PV effect in 1839 using copper oxide in an electrolyte. Radiation from the sun (sunlight) hits a PV cell to create the

PV effect. PV cells are made up of two layers of semiconducting material, usually silicon, that have been chemically treated. These layers are typically referred to as P and N. Figure 4 below depicts a schematic of a PV cell. The boundary between P and N acts as a diode allowing electrons to move from N to P, but not P to N.



When photons with sufficient energy hit the cell,they cause electrons to move (from N to P only) causing excess electrons in the N-layer and a shortage in the P-layer.

This voltage difference is typically in the range of 0.5V for as long as the cell is in sunlight. If shading, such as cloud cover should occur, the performances is significantly affected. The voltage pushes the flow of electrons or 'DC current' to contacts at the front and back of the cell where it is conducted away along the wiring and circuitry that connects the cells together. When the cells are arranged in series, it is called a PV panel.

These panels can be used individually or connected to form arrays. There are a wide variety of PV cell types which can range in size from smaller than a postage stamp to several inches across. The cells are typically less than the thickness of four human hairs. PV cells are composed of semiconductor material, meaning this material combines some properties of metals and some of insulators.

The photovoltaic (PV) effect is the process of converting light (photons) into electricity(voltage).

II. SOLAR WATER HEATERS

There are a wide variety of designs for solar water heaters. Each system consists of a collector and storage tank and use the sun's thermal energy to heat water. Three types of collectors include: batch collectors (also called Integrated Collector-Storage (ICS) systems), flat plate collectors, and evacuated tube collectors. There are also several types of circulation systems which include: direct, closed-loop (indirect), active (forced-circulation), and passive.

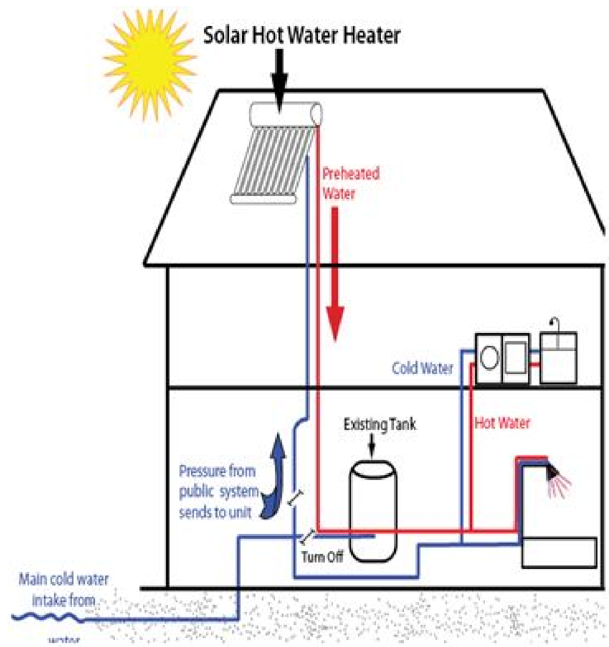
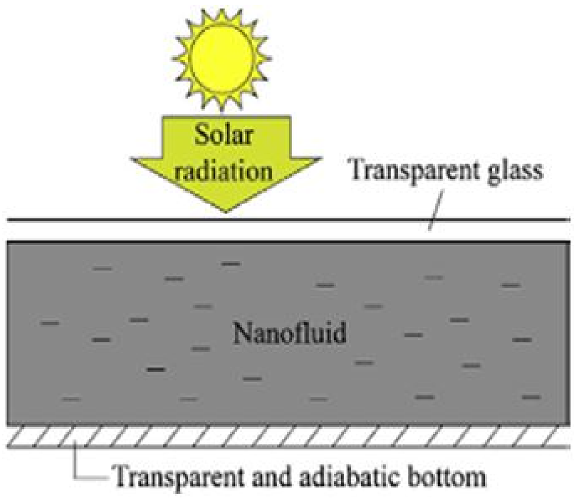


Figure shows a basic schematic of a solar hot water system which is located on the roof of a home. The system depicted is an evacuated tube collector with an active flow circulation and directly uses the work fluid which would be the water.

III. NANOFLUID-BASED DIRECT ABSORPTION SOLAR COLLECTORS

The concept of direct absorption solar collector (DASC) was originated in the 1970s as a simplification to solar thermal collector design and as a way to potentially enhance the efficiency by absorbing the energy with the working fluid. DASCs have been proposed for a variety of applications such as water heating. The efficiency of traditional DASCs is limited by the absorption properties of the working fluid. Nanofluid-based DASC has been tested as an alternative to traditional methods. A schematic of proposed nanofluid-based DASC is shown in Figure .



Nanofluid DASC utilizes certain nanoparticles (such as grapheme) placed inside of a working fluid to absorb solar energy directly within the fluid itself. The highest temperature is in the working fluid and the overall conversion efficiency of energy from solar radiation to thermal form would be improved due to reduced re-radiation heat loss. This is known as the thermal trapping phenomenon. At the nanoscale, the specific surface area is increased and optical properties are more adjustable, which allows for more efficient solar energy utilization. Nanofluids are not transparent to solar radiant energy and absorb and significantly scatter solar irradiance passing through them, which is why they are an excellent option to increase the photo thermal conversion efficiency of direct absorption solar collectors. Nanofluid-based DASC has been shown to improve efficiency of DASC with improvements of up to 5% in solar thermal collectors by utilizing nanofluids as the absorption mechanism.

IV. CONCLUSION

People in all types of climates should consider using solar energy technology as an alternative to traditional heating, cooling, electrical energy, and water heating methods because the technologies are mature, many people have some experience with these technologies, and the mature technologies are cost effective.

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