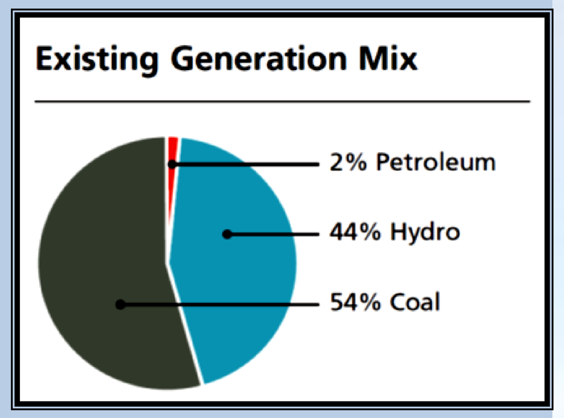
Montana Schools on Solar: A Sustainability Analysis of a Green Initiative

Overview:

In Montana, a very small percentage of electricity comes from renewable sources which in this case is almost all from Biomass Solar energy can play a key role in creating a clean, reliable energy future in Montana.



Consumers who use these technologies will benefit directly and immediately. Solar energy is an excellent alternative to fossil fuels for many reasons:

- It is clean energy. Even when the emissions related to solar cell manufacturing are counted, photovoltaic generation produces less than 15 percent of the carbon dioxide from a conventional coal-fired power plant.
- Using solar energy to supply a million homes with energy would reduce CO2 emissions by 4.3 million tons per year, the equivalent of removing 850,000 cars from the road.
- Solar energy uses fewer natural resources than conventional energy sources. It is estimated that the amount of land required for photovoltaic (PV) cells to produce enough electricity to meet all U.S. power needs is less than 60,000 square kilometers, or roughly 20 percent of the area of Arizona.

Based on the wide availability of solar potential across the sate of Montana, there are growing numbers of funded programs in Montana that are working on providing green, cost efficient energy source for commercial and residential buildings.

Introduction to Sun 4R School Program:

The Sun4Schools project, funded by North Western Energy's Universal System Benefits Charge, resulted in the installation of 2-kW photovoltaic (PV) systems at 27 schools between 2000 and 2003. The main objective of the project was to demonstrate the benefits of solar energy while providing a unique educational opportunity for students and their communities. Of the roughly 3,000 kWh per year produced by each 2-kW system, about 1000 kWh will be provided to the utility grid and 2000 kWh will be used directly by the school. These systems can be expected to produce electricity at about $0.24 per kWh.. Each school is equipped with PV modules to make up an array with an output of approximately 2-kW (peak). The modules are framed and composed of flat-plate multicrystalline silicon cells. The modules have a UL 1703 listing and are warranted by the manufacturer to provide no less than 90 percent of rated power for 10 years, and 80 percent for 20 years. My project is seeking to assess the benefits of this program in larger scale application.

Methodology:

My main data sources are basically the Annual Solar potential in KWh/m2/day obtained from NREL (National Renewable Energy Laboratory) online data base and the locations of Schools that was provided by Montana's GIS portal. The analyses start by identifying the schools whose solar potential exceeds 5 KWh/m2/day. This amount is categorized as "Very Good" solar potential based on the NREL datasets which basically includes the southern counties of Montana. Next step was to measure the area of all the schools in this category whose roofs are flat and suitable for PV panel installation. In general, PV modules could be installed on any roofs however, due to error associated with measuring areas of non-flat roofs in ArcGIS, I decided to stick with flat roofs. At the end of this stage, a total of 83 Schools' roof areas were measured and an extra attribute was added to each school's data. Then, these school's data were joint by census data to obtained each city' population and number of schools in each city to assess the number of consumers that could benefit from this program aside from students of each school.

Analysis:

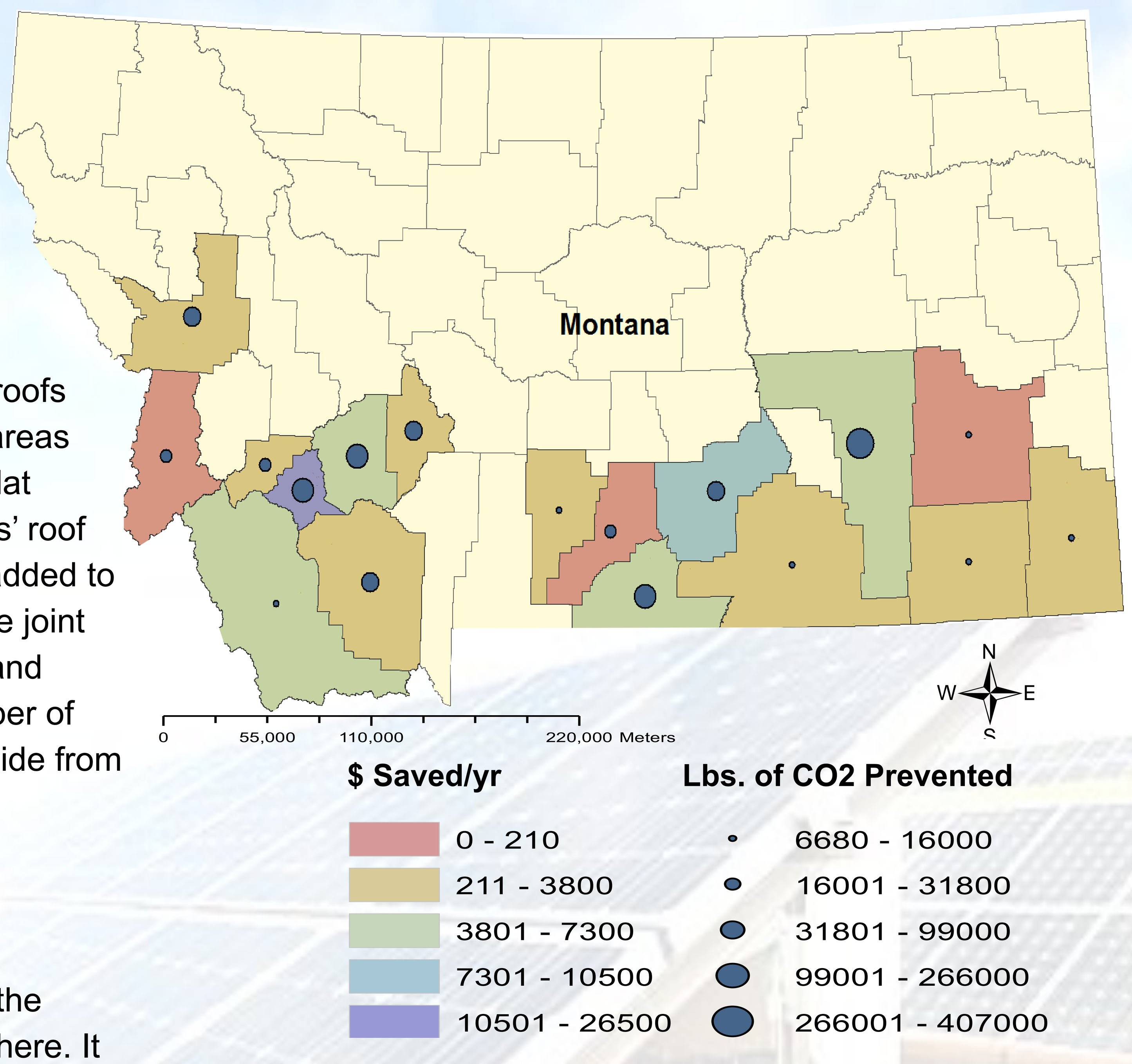
Environmental Benefit:

Potential benefit is defined in two aspects. One is the amount of CO2 emission prevented to the atmosphere. It is estimated that per 1 Kwh of solar energy there is 1.4 lbs. of CO2 prevented to be emitted to atmosphere. The other aspect is the number of potential consumers whose annual electricity needs could be covered by this program in each city.

General assumptions regarding efficiency of these solar modules are their conversion rate of 16% which is defined as the KWh of energy produced per KWh solar energy; 0.8 losses in efficiency in PV modules and 4.5 hour average peak sun exposure in a day in Montana.

Cost Benefit:

According to Northwestern Energy Website solar PV systems cost about 3$ - 5$ per watt. Battery Storage will add up 3000$. This is before tax credits and rebates. With those included, the cost would be cut almost in half. It is



good to know that solar PV systems are typically maintenance free. Most Montana homes consume 8000 - 10,000 Kwh per year and the average consumption per capita is around 4500 KWh per year. Using these information and the amount of potential electricity we can harvest at each school along with average individual electricity consumption, the fraction of population in each city that could benefit from installing these PV cells on the city's schools' roofs was calculated.

Based on NREL website, a 2KW Multicrystalline Silicon Cell in a "Very Good" potential region in Montana could save around 200$ in utility bill per year. Therefore an average saving of 5$ per square meter per year is expected for each school over the life of the PV cell which is typically 20 years.

Limitations:

The results are assuming an ideal situation where the entire roofs are covered by PV cells and the amount of solar energy available at each site could be harvested at the ideal conversion rate. Moreover, the cost of transferring electricity to other consumers surrounding the school's area was not incorporated in the final cost savings result. Also, it is assumed that the electricity produced by this system could be used directly for heating purposes, whereas it is not practically possible and there are other solar systems that are exclusively for heating purposes.

Findings:

This analysis suggest Montana offers substantial solar potential especially in remote regions of the state with lower population density. This is a great advantage for Montana to exploit this sustainable and reliable energy for areas for which cost of transmitting energy is higher. Sun 4R School program along with other solar-for-school programs are growing throughout the state of Montana and by educating students and at the same time their families they are trying to expand this technology for house roofs as well.

Cartographer : Negar Dastjerdi for CEE 187 December 2011
Department of Civil and Environmental Engineering

Coordinate System: NAD_1983_StatePlane_Montana_FIPS_2500
Data Source: Montana GIS Portal, NREL, Census Data

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