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Electricity self-sufficiency: A case study from Mexico

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The numbers are staggering and surprising. If humanity could capture one tenth of 1% of the solar energy striking the earth – one part in one thousand – we would have access to six times as much energy as we consume in all forms today, with almost no greenhouse gas emissions. Yet solar power is still a miniscule fraction of all power generation capacity on the planet.

A photovoltaic (PV) system connected to the existing electricity network represents one of the best options to evade increasing electricity rates during economically challenging times and avoid the emission of greenhouse gases that exacerbate the warming of the planet, a problem caused by the few but whose consequences are suffered by all.

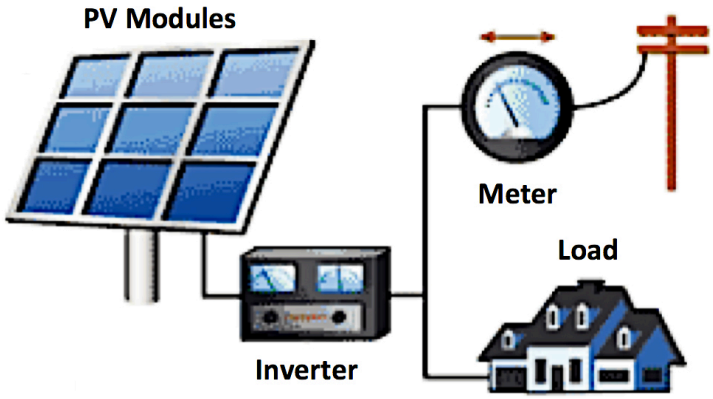

Diagram showing the connection to the grid.

This article provides the example of the use of a small PV array (14.87 m^2) and an inverter for the connection to the grid (Figure 1) to satisfy the requirements of an average family (4 adult members) in Mexico, without the use of an energy storage device (usually heavy, expensive, inefficient, and built with materials toxic enough to eliminate the environmental benefit of generating energy without burning fossil fuels). During the day, the system transforms solar energy into a direct electric current that is converted to an alternate current, and then is either used or introduced into the grid; the injected energy can be recovered from the grid for nocturnal use and so the metre needs to be bidirectional (net-metering scheme).

Since there are no moving parts, the system is maintenance free; the only limit is the life of the PV cells that varies from 20 to 25 years during which the efficiency of the PV cells is guaranteed to remain at above 85% of its original value. Therefore, after the original investment (including installation) is fully recovered in 8 to 9 years (depending on the regional price of electricity) you still get another 11 to 17 years of free, non-polluting electricity. Due to the modular nature of the array, its installation can be performed in partial segments; this in turn eases the affordability of the corresponding investments.

The system can be monitored via a computer or smart phone to examine the amount of daily/monthly/yearly/total generated energy, the amount of CO_2 that has not been emitted to the atmosphere as well as any real-time fluctuations. Figure 2 shows the electricity generated during four full years (kWh, blue), the amount of CO_2 avoided (kg, green), and the lapse of solar light (hrs, red). During the rainy season the presence of clouds disperses the solar radiation and the PV cells efficiency diminishes by 4.3% (valleys in blue line when red line peaks).

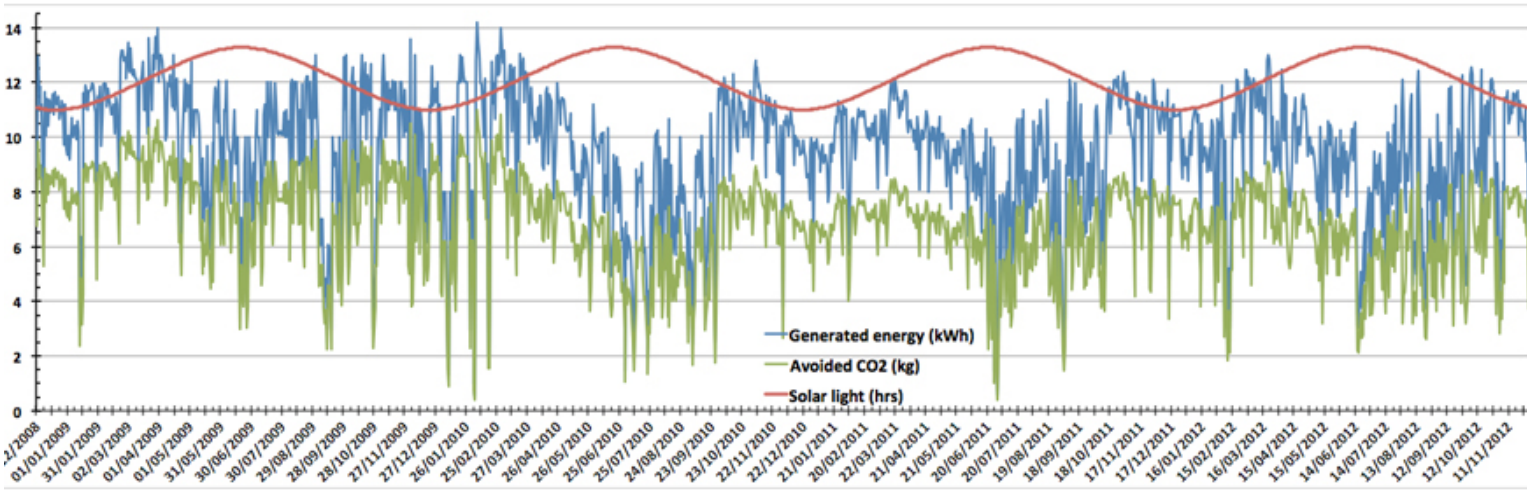

Figure: Daily generation of energy (blue line), CO2 avoided (green) and solar irradiance (red)

The average values obtained with the system during the 4 initial years are: a generation of 3,550 kWh per year, the avoidance of emitting 2.5 tonnes of CO_2 every year, and the recovery of $1,550.00 USD per year. The system is installed in the south of the Southern Sierra Madre in Mexico, a very high-risk zone for electric storms and lightning, however to date the system has not undergone any damage.

The cost of PV-cell panels has been decreasing since 1980 with an annual trend of 7% reduction in dollars per watt, and it has been predicted that the cost of solar electricity will decrease to a level beow the average retail electricity price of 12 cents per kilowatt-hour around 2016. This retail price however does not consider the externalised costs related to the damage being done to the environment by the generation of electricity via burning fossil fuels. If we consider the extra expense of health problems caused by air pollution alone, the average retail electricity price would rise well above any electricity generating clean process like the conversion of solar energy. A sustainable and secure energy system has to incorporate the cost of all the invaluable services that a healthy, unpolluted environment provides us.

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