
Solar Thermal Break-Even Analysis

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The deployment of solar renewable assets carries a certain amount of intrinsic value in the form of carbon footprint reduction and increased energy independence. However, these factors alone are not enough to make a sound business decision. A proven understanding of relevant financial regulations and accurate solar energy modeling are needed for the break-even analysis.

The break-even analysis is conducted in such a way that the quotient, in years, is equal to the time required to have saved, recovered, or offset spending equal to the capital investment deployed. A simplified version of the equation is shown below to illustrate the two drivers in the analysis.

$$t = \frac{P}{A}$$

Where t is the number of years required for an annualized return of A to equal the initial investment of P.

The annualized return is dependent on many factors. Government credits for implementing solar resources, for offsetting natural gas and electricity usage, special depreciation schedules for renewable resources and many others all contribute to the effective annualized return. These factors are especially beneficial to cash-flow positive companies, through tax avoidance, and reduce the break even time more quickly than incremental technology improvements alone do. These factors, however, have varying clocks attached to them and as they expire, so too do their strong benefits. Deductions and depreciations are almost always grandfathered to organizations after they have expired if they were claimed prior to expiration.

$$A = \text{Credits} + \text{Tax Avoidance} + \text{Energy Cost Avoidance} + \dots$$

The initial investment is determined by the type of technology to be implemented: flat panel, evacuated tube, etc. Its characteristic specific cost in dollars per kilowatt delivered (SC_x) is multiplied by the heat rate delivered (q'_{del}) for the process: blanching, drying to yield the initial investment (P).

$$P = SC_x \cdot q'_{del}$$

The heat rate required (q'_{req}) is defined through an energy audit of an appropriate process and is equal to the heat rate delivered. Renewable



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process heat (solar, biogas, etc.) is best implemented as a pre-heater in series with existing plant process heat. This method assures that the final temperature and flow rate at the end point is maintained.

$$q'_{del} = q'_{req}$$

Insolation is the heat rate from the sun per unit area, often measured and reported in watts per square meter (W/m^2). Insolation is also called irradiance in the literature and both terms are accepted. Air temperature and wind speed are the other prime ambient drivers to the system output. Other site specific ambient affects such as wind direction, relative humidity, proximity to process steam venting and array soiling must also be considered. In simple terms the heat rate delivered is:

$$q'_{del} = \eta_{system} \cdot I_n \cdot A_{dep}$$

Where the total system efficiency (η_{system}), is multiplied by the expected insolation (I_n), and the area of the array deployed (A_{dep}) to generate the heat rate delivered. This deterministic type of analysis lacks the actual statistical deviations of the weather, the technology itself, and any other prime drivers defined by the client.

Therefore, to make a more accurate prediction, reduce risk, and increase capital efficiency, the stochastic approach is used. The annual expected heat rate delivered is a complex interaction of mean (μ_x) and variance (C_x) performance metrics of the deployed technology, expected insolation, air temperature, and wind speed. Expected availability of the deployed resource (Avail) must also be included and is understood through mean time to failure (MTTF) data provided by the equipment manufacturer. When coupled with the appropriate weather and process data sets, the actual stochastic heat rate delivered becomes:

$$q'_{del} = Avail \cdot \eta \left(\prod_{i=0}^n [\mu_{x_i}(1, C_{x_i})] \right) \cdot \mu_{I_n}(1, C_{I_n}) \cdot A_{dep}$$

Technologies that utilize solar resources are best used together with deployable resources when those deployable resources are available. Sites without access to deployable resources (off-grid sites) must oversize their arrays and count on energy storage methods to maintain operation at night and during periods of inadequate solar input.

Treating the output of any solar array as a variable resource dependant on changes in the weather allows a target confidence interval to be defined and met. Implementing the solar resource as a pre-heater allows for instantly deployable heat sources (natural gas, electricity, etc.) to assure process temperatures and flow rates are achieved without fail.



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