Understanding Renewable Energy Production

While in general, investing in residential renewable energy makes economic sense, there are still a number of considerations that affect one's perceptions of how good the investment really is!!

The following paragraphs will discuss some of the "realities" of common residential renewable energy systems, namely solar domestic hot water heating (DHW), photovoltaic (PC) electricity generation, and wind electricity generation.

Installing solar hot water heating in new construction is a "no-brainer" and, in most cases, is applicable to existing homes. In order to minimize maintenance, whether preventive or corrective, one does need to install systems that are appropriate for the expected usage and actual geographic location. Some considerations include:

1. Solar DHW systems are intended for year round operation; therefore, sizing must look at peak production during the summer, even without peak usage. This is critical in order that the systems do not overheat, either the mechanical components or the heat transfer fluid. Systems can be covered to prevent overheating.

2. Panel orientation is critical. Obviously pointing south is of prime importance to optimize insolation. Elevation is also critical, i.e., panels should be mounted at one's latitude + 15^{o} (minimum), so that incident solar radiation is balanced, i.e., maximized during the winter and minimized during the summer.

3. All possible joints should be brazed; otherwise, use threaded joints designed to withstand fluid pressure (either with thread design or with use of the appropriate sealant).

4. The expansion tank must be sized for the maximum expected ΔT, given the volume of heat transfer fluid, this will minimize the possibility of lifting the pressure relief.

5. All pipes should be insulated with high temperature pipe insulation to prevent unnecessary line loss of heat.

6. If possible, flow rates should be optimized to maximize heat transfer for the entire system, i.e., optimizing the flow through the collector must be balanced with optimizing the flow through the heat exchanger.

Photovoltaic (PV) modules are the most common and easiest to install form of generating renewable electricity. Since the modules are rated at conditions almost never achieved in reality, the actual output will always seem less than what one thought the "name plate" rating was supposed to achieve. Some considerations include:

1. PV modules output is inversely proportional to the temperature on the back of the module; therefore, modules should be mounted with as much airflow to the backside as possible, e.g., mount on a rack on a pole, not on the roof.

2. Dual-axis trackers can increase the daily output by >40%, even a single-axis tracker greatly improves total output.

3. Insolation is significantly affected by clouds and pollution, as well as altitude. Since most people live in cities that are at low elevations, the insolation is much less than the test conditions the modules were rated at.

4. There are a number of losses when going from the sun's photons to usable AC. The transfer of DC from the PV modules to the inverter should be at the highest voltage possible, since wire loss is proportional to current not voltage. One should use at least one wire size larger than the minimum recommended for the expected current, there is no added cost for installing a larger wire (costing a little more) that minimizes line loss.

5. Inverter conversion efficiency is a function of loading, i.e., the highest efficiency is not at the highest load. Therefore, while one does want to properly size the inverter to the PV array, when running at peak generation, there will be some additional losses.

While wind generators cost less than PV for each installed watt, wind is much more variable than solar, so the output varies significantly. Some considerations include:

1. The actual wind velocity is rarely as much as the perceived wind velocity. Since the power output is proportional to the cube of the wind velocity, the actual velocity needed to achieve significant (50% or more of nameplate rating) is much higher than what one "feels" or thinks is a lot of wind. Note, the wind is usually at a higher velocity the higher one measures above ground, so taller towers do improve output. In addition, taller towers have more laminar wind flow, i.e., less turbulence, with extends the life of the bearings.

2. Wind generators are rated a sea level and standard temperature. Since the air density (energy available to the wind generator) decreases with altitude and higher temperatures, one gets less output at elevation, e.g., >16% less at 5000 feet.

3. As with PV, the output of the wind generator must be converted to usable AC. The efficiency loss there is often > 15%.

4. Since ½ to ½ the cost of a wind generator is for installation, e.g., the tower and supports. Therefore, one should put the largest possible generator on top of the given tower size and support structure. As with PV, use at least one wire size larger than the minimum required.

5. One should have anemometer measurements at the actual location for the wind generator installation, so that a realistic expectation of output is available.