Long Term Output of Grid-Tied Solar Electric Systems

An Interim Report

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Abstract

This is a report on the deterioration of the output of grid-tied solar electric systems over time. Commercial and residential systems are included. The capacities of the solar arrays range from 1.25 kW dc to 455 kW dc. Initially, 25 systems were in the study, 19 systems remain. The monthly output of each system has been recorded since the systems were installed. The most recently installed system is 10 years old; the oldest is 15 years old. All systems in the study are located in the northeastern US. The recorded output includes that of the inverter and the array. String-inverters are used exclusively. Excel's Trendline function is used to project system output from each system out to 20 years, based on recorded output. Causes for system output deterioration are given. Four different types of solar electric collector modules are included. Two studies of historical system output are referenced.

Keywords:
[Solar electric collectors, grid-tied solar systems, long term deterioration of solar electric systems, fixed-mount solar electric systems, sun-tracking solar electric systems, string inverters, intermin report.]

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1. Introduction

This is a report on the deterioration of the output of grid-tied solar electric systems over a period of 20 years. Charts were prepared to illustrate the rate of system deterioration. The study is a work in progress.
The oldest system has been tracked for over 15 years. Another iteration will be published in about 5 years, when the oldest study in this group of systems has been in operation for 20 years. The main factors affecting the output of the systems studied here are listed.

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2. Timing

At the time this study was begun, 2006, other studies of grid-tied solar electric system deterioration were difficult to find. The first extensive study of the subject, referenced below, was published in 2012. It is quite thorough, but was not found until some years after this one was underway. By that time, continuing with this study seemed worthwhile.

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3. Selecting The Systems

The systems included in the study were chosen mainly because the system owners agreed to make the output data from their system available on a monthly basis, for an extended perior of time. That extended period could be for as long as 20 years. An effort was made to include about the same number of residential and commercial systems in the study. The capacities of systems studies range from 1.25 kW dc to 455 kW dc. Initially, 25 systems were in the study. That number was chosen to limit the time required for the study. The monthly output of each system has been recorded since the systems were installed. The most recently installed system is presently 10 years old; the oldest is 15 years old. All systems in the study are located in the northeastern US. Of the original 25 systems in the study 19 remain. Most owner's agreed to supply data on a monthly basis provided that their contact information not be made available to others.

Selection and/or peer review under responsibility of Scientific Committee
doi:10.18086/solar.2020.01.05 Available at http://proceedings.ises.org

4. Types of Cell in Arrays

Four Different Types of Cells are in the arrays:

- Single or mono-crystalline;
- Multi or polycrystalline;
- Amorphous silicon;
- Semi-Crystalline,

5. Acquiring Data

Data is recorded monthly. The data supplied by the system owners includes the date and time of the reading, the inverter output in kWh. As a check on the inverter kWh meter, a utility-type meter is also included in several systems. Owners of the residential systems send in their data by email. The data for most of the commercial systems is obtained from webbased data logging sites. Owners of commercial systems that are not connected to the internet supply data in the same manner as the owners of residential systems. The output recorded includes that of the array plus the inverter. The two components are not read separately. String-inverters are used exclusively.

6. Soiling of the Glazing

No attempt was made to clean the collector glazings and thus improve the system output. Not because it isn't worthwhile but because few of the systems were available to the author. Also, after a few years of ownership few owners showed much enthusiasm for cleaning their collectors. Thus, the recorded output of the systems in this study reflects a worst case condition. at least due to soiling of the cover.

7. Analysis:

Monthly output data for each system is entered in a spreadsheet. The output is averaged yearly. Further, the rate of deterioration is projected for each system based on historical output. The Excel Trendline function is used to project the system output over a 20 year period.

8. Observed Causes of Output Deterioration

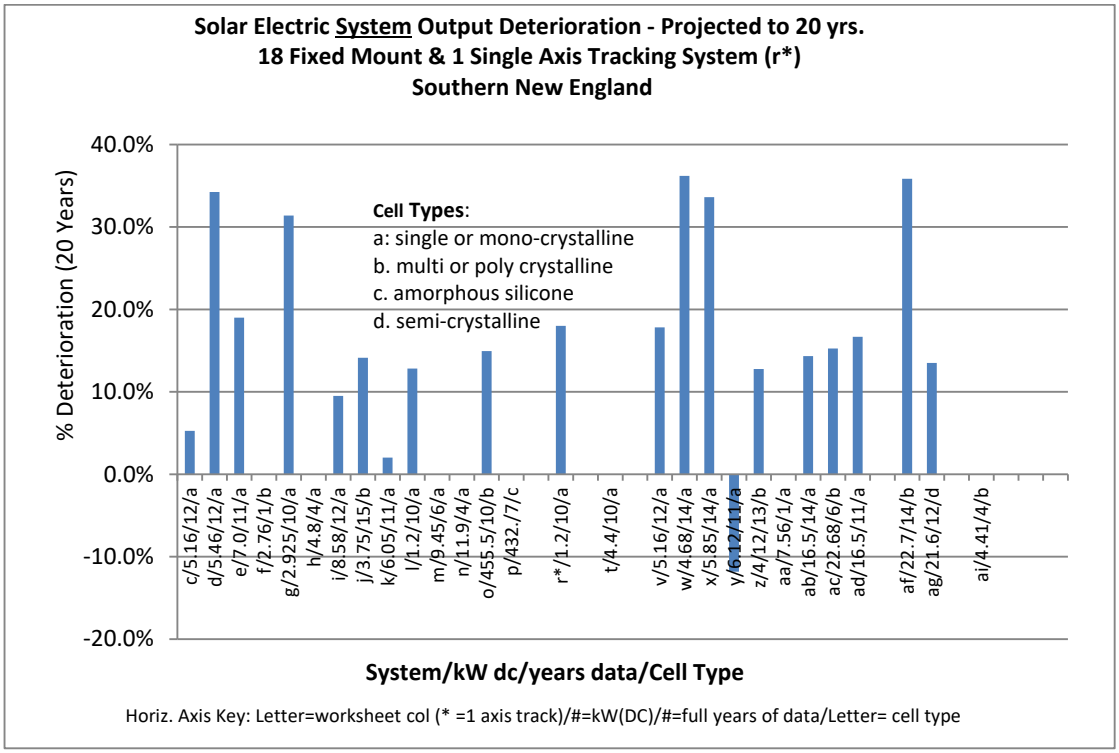
- Inverter mal-function: Many inverters have been replaced or overhauled after 10 years;
- Owner's inattetion to system output & procrastination once output loss discovered;
- Owner's difficulty in finding a capable service contractor;
- Difficulty finding webbased data logging service;
- Subtile output loss due to shade caused by tree growth;
- Incorrectly sized replacement string fuses;
- Inverter fuse damage due to lightning;

- Electrical shorting due to squirrels chewing on wiring insulation underneath the modules;
- Long term deterioration of the cells in the modules;
- System shut off for reasons such as: building vacant; backup generator testing; maintenance; then owner neglecting to turn system on again;
- Array removed due to reroofing, remounting delay due to unexpected cost; sysem abandoned by owner due to remounting cost;
- New inverter required due to owner enlarging original array which eliminated system from this study;
- Ownership changed, new system owner ceased reporting output data.

9. An Output Anomaloy

System ‘y’ in Fig. 1 below shows a gain in system performance over 11 years of observation. This is contrary to all the other systems and contrary to what is to be expected. The gain over the 11 year period seems to be due to the approximate 4 year-long reduction in system output between about 2012 and 2014. During that time the owner struggled to find a competent service technician to correct the system problem. When one was found the technician determined the reduction in system output to be due to improperly sized string fuses installed between the inverter and the solar arrays. When fuses with the correct ampacity were installed the system output increased significantly. It remains to be seen if the longterm output trend is gradually downward after 2016.

Fig. 1: Projected Output of 19 grid-tied systems – kWh ac/m^2/yr



As the systems continue to age the height of the above 'bars' are expected to lengthen.

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