Performance Index Software for the CEC/SMUD ReGen Program

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ABSTRACT

The Sacramento Municipal Utility District (SMUD) has over 700 grid-connected PV systems within its service territory. Dedicated *Performance Index* (PI) software, developed by Southwest Technology Development Institute (SWTDI), enables SMUD's Renewable Generation Assets Department to automatically identify underperforming systems and schedule them for inspection and repair.

NCPV and its component organizations have a long record of providing essential engineering support to critical segments of the nation's PV community. In this service, SWTDI has supported the operator of the world's largest distributed power system: the Sacramento Municipal Utility District (SMUD). With this new software tool, better service will be available and better performance realized by SMUD's growing number of PV customers. In addition, engineering analysis of the large database of SMUD PV systems will provide NCPV with an unparalleled source of performance data covering the spectrum of crystalline, poly-crystalline, and thin-film technologies in real-world use in Sacramento.

1. The SMUD Solar Program

SMUD launched its PV Pioneer I Program in 1993 [1]. Today there are over 600 PV Pioneer residential and commercial rooftop PV systems supplying a combined generation capacity of over 2 MW to the SMUD grid. All of the 2-3 kW PV Pioneer I systems (see Figure 1) are owned and operated by the utility and connect to the grid on the utility side of the meter. Participants provide a residential or commercial roof-top to host the array and voluntarily pay $4 per month in addition to their normal utility bill. This level of volunteerism characterizes the SMUD Solar Program and the utility adds approximately 100 Pioneer I systems per annum.

Figure 1. Typical SMUD PV Pioneer I system.

In 1999, SMUD began its PV Pioneer II Program under which customers purchase the PV systems that are mounted on their roofs. SMUD provides the service of bringing many PV customers together in order to "buy down" the cost of PV through bulk purchase. Pioneer II customers further receive the state-offered PV system rebate and all of the benefits of utility net metering.

In addition, SMUD coordinates its Neighborhood PV Pioneers which have placed 35 commercial and municipal rooftop and parking lot systems totaling an additional 1.5 MW of generation. Figure 2 shows Sacramento's first Community Solar site, the 3.7 kW PV system located at the Sacramento Zoo. SMUD has a development program for churches and schools, both of which can often provide large roof areas with unobstructed solar access. And finally, SMUD has experience dating back to the 1980's with large, substation-tied hundred-kilowatt and megawatt sized PV systems, several of which are in operation today.

Figure 2. Sacramento Zoo 3.7 kW PV array.

2. SMUD and the California Energy Commission

SMUD is a key partner with the California Energy Commission (CEC) under its Public Interest Energy Research (PIER) Program. The PIER Program is designed to improve quality of life in California through development and promotion of environmentally safe, affordable, and reliable energy services and products. PIER RD&D efforts have focused on working collaboratively with private industry, national labs, not-for-profit research entities, and academic institutions to solve major issues in the effective deployment of California renewable energy systems.

SMUD is managing the CEC/SMUD Renewable Generation (ReGen) Program, a multi-million dollar effort to solve fourteen critical RD&D issues related to enhanced performance and cost reductions in PV systems, biomass applications, evaporative cooling, and concentrating solar dish stirling engines. One of the technical objectives designated for the CEC/SMUD ReGen Program was the development of *Performance Index* software for support of SMUD and its PV customers.

3. The SWTDI-developed *Performance Index* Program

SWTDI, with technical guidance from Sandia National Laboratories, has been providing DOE-funded engineering support to the U.S. PV community for over 20 years. This support takes many forms, including: hardware monitoring; software development; performance and life cycle cost analyses; and training. In 2002, SWTDI offered its support to the CEC/SMUD ReGen Program and was asked to develop the *Performance Index* program (PI).

Several components are required for implementation of the PI program: automated provision of the SMUD monthly meter data for all PV systems; automated daily collection from a suitable solar radiation monitoring site; implementation of solar radiation translation algorithms for each PV orientation over the billing period; development of the performance index algorithm to estimate PV system output corrected for measured solar and temperature data; and finally, an intuitive interface to simplify running the program each month and assessing its results.

The SMUD IS department provided the necessary SQL to extract monthly billing records for each PV system from SMUD main frame computers. The solar translation algorithms used were those compiled by Martin Rymes [2] and placed into the public domain as C language subroutines by NREL. The bulk of the PI program was written in Visual Basic 6 and runs on a Windows-based computer.

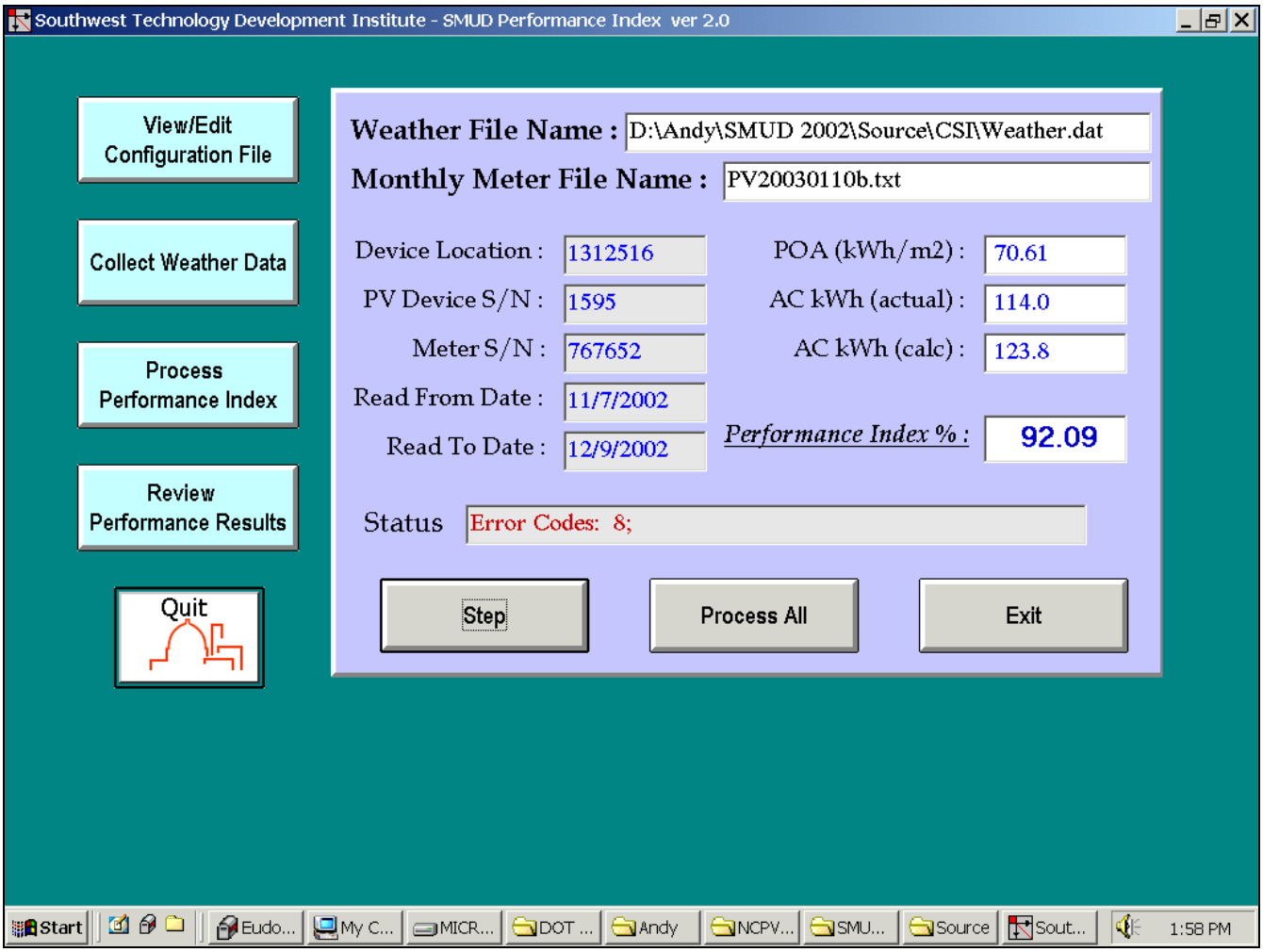

Figure 3. Screen-print of the SMUD *Performance Index* Software showing calculated results.

4. Early Results

Since installation in early February 2003, the SMUD PI program has yielded valuable early results. Already, previously unknown performance problems related to shading and improper installation have been uncovered in systems. The sorting of PI statistics by module type (crytalline, poly-crystalline, thin-film) has begun to show intriguing trends that will be studied in the months to come. Since meter and solar data records go back for 9 years, the

evaluation of PI statistics over the life of older systems will shed light on performance and degradation trends

5. Conclusions

SWTDI, DOE and NCPV have provided support to the nation's largest collection of PV users and the utility that provides their electrical service. This support has taken the form of development of customized, *Performance Index* (PI) calculation softwaret which will be used to identify and then fix problems in both utility and customer-owned PV systems. SMUD's use of the software and associated follow-up process will result in more satisfaction among the PV system owners and users of Sacramento.

In addition, the PI software can now be systematically used to assess the archived PV production data recorded by SMUD over the past 9 years of its photovoltaic program. Performing this analysis using the large data set of the SMUD PV system database, will provide valuable insight into nine years' of PV system characteristics including performance degradation and reliability trends, both of which are topics of great interest to the PV community and the NCPV.

REFERENCES

[1] Donald Osborn, *SMUD: a utility helping create the solar century*, Renewable Energy World, September-October 2000, pp. 52-60.

[2] Solar Position and Intensity Algorithm, obtained from http://rredc.nrel.gov/solar/codes_algs/solpos/, compiled by Martin Rymes et. al., distributed by the National Renewable Energy Laboratory.