Power to the People: The Benefits of a Decentralized Reporting Strategy for Tracking the Performance of Publicly Funded Renewable Energy Systems

David Beavers, Shawn Shaw, and Emma Kosciak, The Cadmus Group Inc, Watertown MA..
Kelly Dexter, Tyler Leeds, and Jon Abe, Massachusetts Technology Collaborative, Westborough, MA.

ABSTRACT

There is growing demand for renewable energy systems. However, there is currently no nationwide standard for tracking and reporting the performance of these systems. Looking forward, this will equally apply to distributed generators of "white tags", as well as continued applicability to distributed generation (DG)/renewable energy (RE) production.

Understanding the tracking/reporting process requires we ask several key questions:

- Why track?
- What tracking systems already exist? How do they work?
- What considerations set small and large generators apart for tracking purposes?
- What level of precision is appropriate for reporting production and Renewable Energy Certificates (RECs)?
- What are the advantages/disadvantages of decentralized reporting?

The authors will show that the long held belief that packaged Data Acquisition Systems (DAS) are necessary to insure accurate and reliable reporting is not always true. With the proper reporting system such as the Production Tracking System (PTS), supported by the Massachusetts Technology Collaborative (MTC), it is possible to interface human and automated reporting systems. This decentralization of the reporting process has several key benefits:

- Identification and correction of malfunctions
- Increases DAS provider competition
- RE system cost reduction
- Increased RE system owner involvement

In this paper, the authors will examine technologies associated with tracking RE system performance, current performance tracking at the state level, the benefits of decentralized performance tracking methods, and recommendations that policymakers can utilize in designing/revising RE programs to reduce program costs, increase public benefits, and improve program participation.

Introduction

Many state agencies offer rebates or programs to support the installation of renewable energy or distributed generation technologies. These programs generally award rebate/incentive dollars based on installed capacity (e.g. $5.00 per Watt) despite the fact that the primary benefit of these technologies is delivered through energy production. In order to ensure that the anticipated benefits are delivered, some system must exist to track energy production. This tracking has a number of important benefits for renewable energy programs:

- Early identification of system failures/maintenance requirements
- Improved owner involvement in system operations
- Accurate verification of program benefits
- Quantitative metrics for measuring installer performance
- Potential for tracking/trading RECs

Though the benefits of performance tracking are clear, there are many remaining issues and questions which must be addressed when designing or evaluating a RE/DG tracking program:

- Allowable accuracy of reported values
- Reporting interval
- Monitoring equipment impacts on system cost effectiveness
- Field verification/audits
- Performance guidelines
- Uses of data collected
- Rebate structure to promote reporting

The authors' experience with the Production Tracking System (PTS), used by the Massachusetts Technology Collaborative (MTC) to track the performance of over 600 renewable energy systems statewide, has provided valuable insight into the potential promises and pitfalls of RE/DG performance tracking.

Current Production Tracking Policies

Massachusetts has the only incentive program where reporting production is integrated as a part of the requirement to receive rebate payment. There is a number of production reporting strategies being used by RE/DG programs in other states, but Massachusetts is unique in its combination of robust, regular tracking requirements coupled with openness to a variety of data collection and reporting strategies.

In some cases, such as New Jersey, energy production is tracked as part of a REC market. New Jersey has structured its incentive program to take advantage of RECs and to provide a very high value for Solar RECs in particular. However, in New Jersey, REC production is tracked by a single vendor solution DAS with statewide access, rather than a free market environment, which allows for multiple DAS vendors to compete for business.

Another tracking strategy is to use engineering estimates, though accuracy becomes a point of question for this method. For example, engineering estimates rarely include estimates for system downtime/maintenance or installation inconsistencies. Data received from system owners in Massachusetts has identified several cases of incorrect installation that, once repaired, significantly

affected the energy output of the affected system(s).

Finally, there are yet other programs requiring production tracking, albeit over a much longer time interval (e.g. NYSERDA, bi-annual reporting) However, as with other methods described above, this data does not seem to be formally tracked, and one could question the percentage of systems reporting with such long lapses between reporting periods. In addition, this long lag time could greatly impact a site's energy production, if a system were to experience a failure between reporting periods and go unnoticed by the system owner.

With no consistency to renewable energy tracking, or method of determining production, several questions arise:

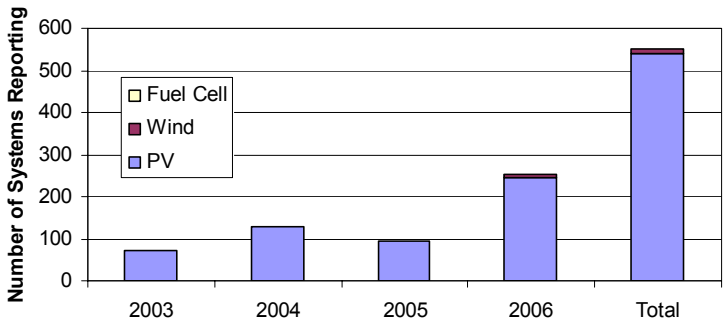
- How accurately are the existing tracking systems measuring energy produced?
- What implications does this have on market trust of REC sales from small systems?
- Are small systems "falling through the cracks" in comparison to large, centralized REC generators?

What is the MTC PTS and How Does it Work?

The PTS was launched in January 2003 after six months of development. Renewable energy systems supported by MTC are "registered" in the PTS by MTC grantees, MTC staff or contractor staff. The registration record documents the static attributes of the system including: grantee, owner, installer, system location, system type, capacity, make and model of equipment, cost of equipment and installation, expected annual production, and date of startup. Designated system representatives report production to the PTS on a monthly basis, using an ANSI certified revenue quality meter on the AC output of the RE/DG system.

The system meter must be read between 5 days before, till 5 days after, the first day of each month. This can be performed by visually reading the meter and entering the reading at the PTS website, or through automated reporting from a DAS. Each system is given a unique "System ID" and is accessed through a username and password, tied to grantees, system representatives, and system owners. Figure 1 shows the number of systems reporting to the PTS, by technology, on an annual basis. Figure 2 shows the cumulative energy production by technology of the various DG systems reporting to the PTS.

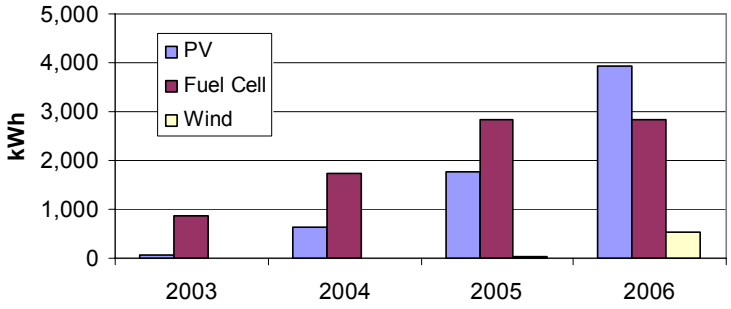
Figure 1: DG Systems Reporting to the PTS



The Massachusetts Technology Collaborative uses the PTS for a wide variety of its programs:

- Clustered PV Installations
- Open PV Installations
- Green Buildings Initiative
- Green Schools Initiative
- Fuel Cell Initiative
- Small Renewables Initiative
- Commercial, Industrial and Institutional Initiative
- Green Affordable Housing Initiative
- Low Income Affordability Network
- Utility Scale
- Large On-site Renewables Initiative

Figure 2: Cumulative Energy Produced by DG Systems in Massachusetts



Overview of Data Reporting Methods

Automated DAS-Offsite Storage

One of the most commonly employed methods of tracking, storing, and reporting data utilizes remote data logging and modem/internet communications protocols. The equipment may be purchased or leased and is generally accompanied by an agreement to automatically report data on a monthly basis to the PTS. The equipment involved includes a module installed on-site and in-line with the inverter output, which is then "called" on a regular basis by a central server. This call returns the current cumulative energy production, where that information is logged in the central server. The frequency of the calls can vary widely but hourly or daily calls are commonly employed. The calls themselves may be connected over a fiber/network connection or over a telephone line. In cases where a telephone line is used, a dedicated line may be necessary if frequent calls from the server are desired. The system can also be set to make/accept calls only during periods where the phone line is not in use, to minimize inconvenience to the system owner.

Benefits:

- Automated reporting requires little attention from system owner
- Offsite storage/server requires no maintenance from system owner
- Depending on DAS provider, issues with system could be identified very quickly
- Access to data for public visibility and outreach needs

Drawbacks:

- Increases up front system cost by approximately $3-$5,000
- Typically includes a monthly or yearly fee

- Potential for large-scale failed reporting or other data quality issues if central server experiences failure or other problems
- May decrease owner awareness of system performance
- May require dedicated communications line

Automated DAS-Onsite Storage

Another option for automated reporting is to place a server at each system location to track and automatically report system performance data. This method is very similar to using offsite storage except that the central server, and associated communications requirements, is removed. The data is accumulated/processed on-site and regularly reported to the PTS from each site's local server.

Benefits:

- Removes the need for a central server/monitoring service

Drawbacks:

- On-site servers are prone to a variety of failures and require considerable maintenance
- Increases up front system cost by approximately $3-5,000 for equipment
- May require a monthly or yearly fee
- May decrease owner awareness of system performance

Manual Reporting-Internet Based

The alternative to automated reporting is to require that grant recipients/system owners regularly report system production via a simple website. The system representative is issued a username and password that they use to log onto a secure site every month. Once identified, the representative can freely navigate the site, giving them access to past production history, system information, and maintenance records. To enter data, the system representative simply records the reading from their production meter and records this information in a simple online form. This data is then saved to the central PTS server.

Benefits:

- Does not require DAS equipment and associated costs
- Very reliable for most users most of the time
- Increases owner involvement/awareness in system performance
- Convenient for system owner
- Data errors affect only single system

Drawbacks:

- Requires periodic effort from system owner
- Requires some education and support for users
- Chance for typographical errors to affect data

Manual Reporting-Phone/Mail

Rather than using a custom website to collect reported data, the method requiring the least up-front development is to collect production data via mail or telephone. In this case, system owners still read system meters but then must write/type their production and other periodic data onto a paper form and turn in the physical form to program administrators. If reporting is done via phone, then program support staff must take the call and enter the reported production data into a tracking system/spreadsheet of some sort.

Benefits:

- Minimal development costs
- Does not require system owners to have internet connection

Drawbacks:

- High administrative costs
- Slow response time for data collection
- High barrier (inconvenience) to regular reporting
- System owner bears high life cycle printing and postage costs

Bringing it Together-the Methods Compared

The strengths and weaknesses of each method, as applied in Massachusetts, can be readily compared in Figure 3. While there is no single reporting method that is a perfect fit for every program type, manual online reporting and automatic offsite reporting both present reliable reporting strategies.

Drawing on experience from Massachusetts, Table 1 displays the administrative burden for a randomly chosen sample of 38 DG systems, 19 each of systems using automated DAS and manual reporting strategies. Examination of Table 1 raises an interesting question, "Is manual reporting more reliable than automatic reporting?" This notion may run counter to the most commonly accepted truism that the average person cannot be relied upon to accurately and reliably conduct self-reporting. However, this is precisely what has occurred in Massachusetts since 2003. Despite the large number of systems reporting to the PTS through a handful of well established automatic reporting systems, examination of the proportional number of administrative requests shows that manual reporters are, in fact, just as reliable as DAS solutions, if not more so). In addition, the majority of administrative requests submitted by manual reporters tend to be very minor, whereas administrative tasks generated due to automatic reporting systems often include more extensive changes. While this trend may not hold true for all markets, it does indicate that allowing multiple methods of reporting (i.e. manual and automatic) may have a beneficial impact on overall reliability and administrative costs. It may also raise overall program effectiveness by removing the compulsory expense of a DAS.

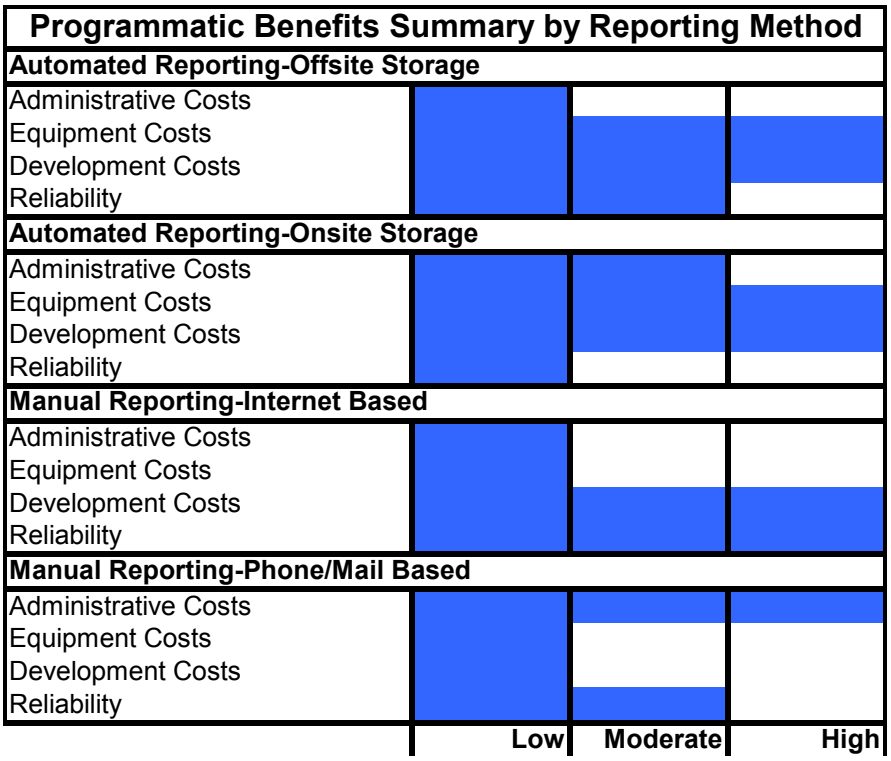


Figure 3: Comparison of Reporting Strategies

Table 1: Administrative Burden of Automated and Manual Reporting Strategies Compared for 38 Randomly Chosen Systems in Massachusetts		
	Automated DAS (n=19)	Manual (n=19)
Instances of Missed Reporting	5	4
Instances of Administrative Correction	10	5

Quality Assurance

In any data set, the need for quality assurance is unavoidable, and production tracking for RE/DG systems is no different. The Q/A process consist of several discrete, but related, steps:

1. Regularly review data set for non-reporters and irregular data
2. Follow up with system representatives
3. Correct errors based on simple software glitches, typographical errors, and first time non-reporters
4. Conduct field audits with repeat non-reporters, first time reporters requiring assistance, and other sites, as deemed necessary on a case by case basis

The first step can be almost entirely accomplished using software searches, but institutional knowledge of "problem sites" or other issues can also play a significant role. To simplify the identification of potential issues, the database can be used to identify unusual entries for a number of variables:

- Capacity factor
- Maintenance events
- System downtime
- Reporting history

Once issues are identified, some may be corrected without resorting to an onsite audit. For example, identified glitches with automated reporting software which submits data for the wrong month would not require an onsite audit. One period of missed reporting is also generally not cause for an onsite audit. However, major changes in capacity factor or a history of missed reports are both good indicators that an onsite audit should be conducted. These audits involve sending a skilled engineer or other staff member into the field. This individual should be familiar with the reporting requirements of the tracking system, the associated software/hardware, and with RE/DG technologies in general. During the audit, the individual should investigate:

- Causes of abnormal capacity factor (e.g. shading, wiring problems, unreported downtime, vandalism)
- System representative's understanding of reporting requirements and procedures
- Accuracy of database with regards to installed components, contact information, and other information recorded during system registration
- Quality, code compliance, and standards of workmanship applied to installed system
- Feedback on the grant process

Required Precision for Production Tracking Systems

Markets, and market support infrastructure, for Renewable Energy Certificates (RECs) are developing rapidly in the U.S. Most RECs represent generation from utility scale power systems that sell wholesale electricity into regional markets. Attribute tracking systems such as the NEPOOL GIS and the proposed WREGIS create certificates by first reading data on generation collected by ISO / RTOs. Generation reporting and verification rules are established and administered by these regional market entities.

Smaller generating systems are also starting to participate - at least in niche markets. The standards for tracking and verification of generation used to claim RECs from these small systems vary significantly from state to state, or even within a state. The concept of uniform regional and/or national standards for tracking generation at small systems is not new. Proposals for such standards, including details on the frequency and methods of reporting, have been put forward in at least one region.

However, to the author's knowledge, there has been no investigation of the underlying needs for accuracy and precision in this reporting. In some jurisdictions, it is tacitly assumed that tracking for systems as small as 1 kW must follow rules developed for generating systems of 5 MW and higher, yet a 1% error in reporting from a 1 kW system is equivalent in real energy terms to a 0.0002% error at a 5MW system, assuming that they share the same capacity factors. This leads to a major question, "What is an appropriate level of precision and accuracy in metering and tracking for small systems?" Several points must be considered when making this assessment.

Most RECs are derived from large generators that report energy generation to transmission level markets and follow meter and quality assurance (Q/A) rules developed for these markets. Smaller renewable generators, some as small as 1 kW, on the distribution side do not have similar systematic and comprehensive rules / procedures for reporting energy production. This has led to questions regarding the confidence that should be placed in RECs generated from small generators.

Most current tracking systems address meter specifications, reporting schedules, manual vs. automated reporting, and other technical issues but ignore a fundamental policy question that, thus far, has not been systematically explored, "What level of precision and accuracy is appropriate for tracking the energy/REC production of small-scale generators?" Though this issue addresses a technical requirement, it is fundamentally a question of policy and economics. Several questions to consider on this issue are:

- Are the rules and procedures developed for large generation and transmission systems too burdensome for smaller systems, many which produce fewer kWh than a typical household consumes in a year?
- What is the dollar impact for a 1 kW system that has more than a 10% production variation is the same as a 1 MW system reporting off by 0.01%?
- What is needed to ensure data integrity / backup in support of REC markets?
- What level of precision and accuracy would be acceptable to REC buyers?

Running a Decentralized Reporting System-An Overview and Recommendations

Operating a RE/DG program that uses distributed reporting to track system performance and production is an increasingly common means of promoting clean energy technologies. Many new programs may be tempted to utilize single vendor reporting solutions, or forego reporting altogether. While these may be an administratively easier method for creating a new program, there are a number of advantages to using an open-source distributed reporting system.

Measure Persistence

Ongoing tracking of system performance insures that incentive dollars are allocated for functioning systems. Regular tracking can be used to quickly identify and troubleshoot system failures, resulting in faster service calls to the installer. Conscientious system owners may regularly check production but, if not overseen by the funding agency or another knowledgeable body, may not be able to adequately identify system problems. For example, if a system is operating but not meeting production estimates due to a wiring problem, the owner may not think to call the installer. In these cases, having the system owner report regularly will trigger a QA audit and the auditor will be able to troubleshoot the system and bring in the installer to conduct repairs.

Program Evaluation Metrics

Regular reporting provides key information on program effectiveness. Annual reporting can be used to inform annual evaluations but will suffer from attrition among system owners, due to the long timeframe between reporting. Program evaluators could conduct audits/meter readings at each system but, for established programs, this quickly becomes an expensive administrative burden. More frequent reporting, particularly monthly reporting, provides more precision and is sufficient to establish the habit among system representatives, requiring comparatively little oversight from program administrators. The greater frequency of reporting also allows for more aggressive program evaluation timelines, allowing greater flexibility and response time for program guideline changes.

Cost Effectiveness

Using single vendor DAS solutions is a costly alternative to distributed reporting. The typical cost for a DAS installed on a typical residential RE system is approximately $3-$5,000. Programs incur additional expenses in administrative fees, customized interfaces, and other features. In contrast, a distributed reporting system can be operated with an inexpensive database, with or without web-reporting capability, and a $50 revenue quality utility meter. Furthermore, the distributed reporting system does not preclude the use of a DAS. Massachusetts uses an open source communication protocol that the system administrator gives to DAS companies, allowing them to interface with the PTS and auto-report for their customers each month. This approach has the added benefit of fostering competition among DAS providers, with various technologies and business models, which drives the market cost downward and fosters innovation.

Once the decision is made to track energy production data for systems funded through an incentive program, there are several key questions that the program manager must answer.

What kind of incentive structure should I use?

There are two commonly employed bases for funding RE/DG systems: capacity or production. In capacity based incentive programs, funding is allocated for each system based on the "nameplate" capacity of the system. For systems with consistent production to capacity ratios (e.g. PV, landfill gas, fuel cells), this is a simple method to provide incentives that will, within a fairly small error band, provide a known benefit. However, the capacity based system may be less suited for technologies where capacity and output are not directly related, such as wind. Production payment systems have the benefit of low risk (payments are only made for actual production) but they do incur additional administrative burden involved with making periodic payments. In addition, a production payment system may not be as attractive to the customer, since the payment will come over time, rather than offsetting a portion of the upfront cost for the system. Finally, there are hybrid approaches that combine characteristics of both production and capacity based systems. A capacity based system might include adders designed to provide extra incentive for systems that will produce more (e.g. tower height multipliers for wind systems). Another example is using a model to estimate energy production for the system lifetime and providing an incentive based on this estimated, rather than actual, production.

How can I insure high quality installations?

The worst case scenario for any program is a situation where a system installed with program funds is somehow unsafe, violates code, or fails to produce the expected amount of energy. This risk can be minimized by adopting a consistent set of requirements for both funding approval and release of funding. For example, a program could require structural engineering plans on a wind project before approving an application for funding but not release the funds until the project had undergone a post installation inspection and engineering review, to insure that the system was installed correctly and in accordance with the approved engineering plans. In any case, inspections by program staff, consultants, or another third party, rather than a rival installation firm are vital to insuring that the paperwork received with the application accurately reflects the as-built system. These inspections are also useful means to identify poor resource availability, such as shading or turbulence, or other factors that could affect the ability of the system to produce energy in a safe and effective manner.

How can I insure continued reporting from funding recipients?

Continuation of program involvement is important to building a robust set of production data for a particular system. The simplest way to insure that system owners continue to report production data or otherwise cooperate with program requirements is to keep a portion of their incentive payment in reserve. The Small Renewables Initiative, for example, requires that customers report their energy production for a period of 12 months prior to the release of the final 10% of their up front incentive payment. Production incentive systems do not typically have this difficulty, since the rebate dollars are closely linked to the customer's regular reporting. Reporting irregularities delay payment and are, therefore, less likely to occur.