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DESIGNING A PERFORMANCE-BASED INCENTIVE FOR PHOTOVOLTAIC MARKETS

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ABSTRACT

In this paper, the author proposes an alternative financial incentive that pays customers investing in PV and other technologies based on the actual energy produced by the system rather than on the amount of money invested in the system. Such an incentive is referred to as a 'performance-based incentive' (PBI). Performance-based incentives have been responsible for spurring much of the growth in the U.S. wind energy industry over the last decade, and have been instrumental in the development of the German PV industry in recent years.

The author suggests that performance-based incentives:

- Are more efficient, because they create incentives for manufacturers, installers, and customers to be more attentive to energy performance; and
- Are likely to defuse political concerns about system quality and performance, since the system providers and/or the customers will only be paid in proportion to the amount of energy produced by the system.

In addition, the author proposes a simple, easily-administered mechanism for a performance-based incentive program that could be implemented in California or elsewhere, and includes:

- A five-year stream of payments that provides financial support equivalent to existing rebate programs (assuming good system performance);
- The mandatory use of utility-grade metering equipment to measure performance; and
- Self-reporting of annual electricity generation to the funding agency, backed by an audit program and severe penalties for misstating energy production.

1. INTRODUCTION

California has created the world's third-largest market for solar photovoltaic (PV) technology by adopting a combination of financial and regulatory incentives that promote direct investment in PV systems by utility customers. The most important of these incentives is the 'buydown' or rebate programs that pays between $3.00 and $4.50 per Watt – roughly half the total installed cost – to utility customers who invest in PV or other qualifying technologies.

Recently, the California rebate programs have become threatened by a combination of (1) higher than expected participation, which is consuming the available funds more quickly than they are being collected from ratepayers; (2) the California budget crisis, which is likely to make additional funding hard to come by; and (3) a decline in political support for the rebate program, driven by the perception – justified or not – that some of the residential systems installed under the rebate program have been poorly designed, poorly installed, or otherwise have performed less well than expected or anticipated.

In this paper, the author proposes an alternative financial incentive that pays customers investing in PV and other technologies based on the actual energy produced by the system rather than on the amount of money invested in the system. Such an incentive is referred to as a 'performance-based incentive' or PBI.

2. PERFORMANCE-BASED INCENTIVES IN THEORY

Performance-based incentives make good public policy sense because they directly reward the production of energy. If the system fails to perform adequately, the system owner receives a lower incentive payment. This encourages the owner to be particularly attentive to the appropriateness of the location and the quality of the design, the equipment, and the installation. The owner's attention, in turn, encourages the system providers – the equipment manufacturers and the installing contractor – to be more attentive to the factors that affect system performance.

Capacity-based incentives of the kind that have been in place in California and elsewhere do serve a purpose. They are particularly well suited for technologies that are emerging from the research and development phase and going into commercial production, where long-term performance and reliability are not well defined. In such cases, a pure performance-based incentive may not be able to attract customers or other investors, because the risk of non-performance is enough to discourage investment capital from flowing to these new technologies.

Although this argument in support of capacity-based incentives may have been appropriate for solar photovoltaic systems even five years ago, it is no longer appropriate today. There are literally thousands of PV systems operating in California. The technology is still evolving, but is well established and relatively mature. Moreover, the infrastructure to serve the market – the network of manufacturers, distributors, and qualified installers – is also increasingly well established. The technology itself is quite reliable.

In fact, most of the performance-related problems in the California program have had more to do with poor siting (shading and orientation) or poor installation (component mismatch, wiring sizes, inverter loading) than with the quality or reliability of system components.(1) This suggests that a shift in the incentive structure to put more emphasis on system performance – and accordingly on siting and installation – is overdue.

3. PERFORMANCE-BASED INCENTIVES IN PRACTICE

Although California's Emerging Renewables Buydown program is the largest of its kind in the U.S. and has influenced a number of other programs to support a capacity-based incentive approach, other technologies and other jurisdictions have seen considerable success with performance-based incentives.

3.1. The U.S. Wind Energy Industry

In the U.S., the most obvious example of success in shifting from a capacity-based incentive to a performance-based incentive is the utility-scale wind energy industry.

During the early 1980s, the first big 'Wind Rush' in the U.S. was spurred by a combination of incentives, not the least of which were the substantial tax credits offered by the federal government and by the State of California. Together, these tax credits effectively produced a return to private investors of over 50% of their initial investment for the year in which the wind facility went into production, with additional tax benefits provided in following years through accelerated depreciation.

These tax credits were tied to the amount of the investment in the facilities (which effectively correlated with the amount of capacity installed) rather than the energy performance of the facilities. Although investors also received a return from the sale of electricity to the interconnecting utilities, the expected return from the power purchase agreements was dwarfed by the tax benefits. As a result, the incentive was inadequate to ensure the use of reliable equipment, or the siting of this equipment in areas with high wind resources.

By the mid-1980s, public allegations of tax abuse were rampant, and the wind industry's reputation was suffering substantially. U.S. Representative Pete Stark, whose district included part of the Altamont Pass developments, was quoted as saying "these aren't wind farms, they're tax farms," among other critical comments.(2) In response, Congress declined to extend the federal tax credits for wind power facilities in the 1986 Tax Reform Act, and new investment in the wind energy industry plummeted.

In 1992, the Energy Policy Act restored federal financial incentives for the wind energy industry. Notably, however, the primary incentive was a performance-based incentive, in the form of a payment of 1.5 cents (adjusted upward in following years for inflation) for each kilowatt-hour produced from a qualifying wind farm. This incentive structure contributed substantially to the re-emergence of the wind energy industry in the U.S. and has remained in place with very little public or political opposition ever since.

3.2. The German PV Industry

With average sunlight levels roughly comparable to the Pacific Northwest region of the United States, Germany has created the world's second largest commercial market for PV technology (Japan is first). This remarkable success has been fueled by the country's so-called renewable energy 'feed law,' which provides a per-kilowatt hour performance-based incentive payment for renewable generation, including solar power.

The current incentive amounts (effective January 2004) provide for a base payment of $0.487 per kilowatt-hour. There are substantial additional premiums for systems that are building-integrated, so that the incentive reaches a maximum of $0.72 per kilowatt-hour for façade-integrated systems under 30 kW.

This program has been the principal driver for the growth of the German PV market, from under 6 MW cumulative capacity in 1992 to over 260 MW in 2002.

4. DESIGNING A PERFORMANCE-BASED INCENTIVE FOR THE CALIFORNIA MARKET

There are several principles that guided the development of the PBI proposed in this paper:

4.1. Spread Incentive Payments Over a Period of Years

The incentive payments should be spread out over a number of years. Spreading the payments serves several purposes. It encourages system owners to be attentive to the quality and long-term reliability of systems, rather than just their 'out-of-the-box' performance. It also helps to smooth out performance differences attributable to inter-annual variations in sunlight and other weather parameters that affect system output.

On the other hand, 'front loading' the stream of payments to the early years of the project makes it easier to secure financing for the systems.

A five-year stream of payments reflects a reasonable balance between these conflicting considerations, and is the figure used in our baseline analysis.

4.2. Set the Performance Incentive Level to Meet or Exceed Capacity-Based Incentive Payments

The discounted present value of the performance-based incentive payments should be at least equal to – and preferably greater than – the value of comparable capacity-based investment incentives. The rationale for this is that virtually all of the risk of system underperformance is being transferred to the system owner, so all else being equal the system owner should receive an additional reward to offset the increased risk.

Defining the PBI payment should be the result of a careful, deliberative process. In California's case, the goal should be to set an incentive level that is likely to sustain the recent growth in the market. There is an inherent risk in switching from a capacity-based to a performance-based incentive, because contractors and their customers have become accustomed to seeing a substantial and near-immediate payback in the form of the rebate payment. Getting the market to accept a stream of payments over several years is not a trivial issue, and is another reason to begin with an incentive payment that is attractive enough that customers would choose it over a capacity-based payment.

Current capacity-based incentives in California are $3.10 per Watt through the California Energy Commission's Emerging Renewables program (targeting residential and small commercial systems, up to 30 kW) and $4.50 per Watt through the California Public Utilities Commission's Self-Generation Incentive Program (targeting commercial-scale systems above 30 kW). For our baseline analysis, we chose a figure of $4.00 per Watt as the incentive level to be met or exceeded by an equivalent performance-based incentive payment.

4.3. Keep the Administration and Enforcement Simple

An obvious challenge in administering an incentive program that is based on actual energy performance is how to monitor generation simply, accurately, and inexpensively. Although there are a variety of options available, we suggest a relative simple approach that relies on standard utility-grade metering, self-reporting of the electricity generated, and periodic auditing of systems to encourage accuracy and discourage fraud.

4.3.1. Metering

Every PV system should have its output metered. Although PV systems in most cases can be connected to the utility grid through the existing utility meter, this configuration does not separately measure the output of the PV system – it only measures the 'net' inflow or outflow of power to the home or business.

The incremental cost of adding a utility revenue-grade meter to a PV system is modest. For single-phase (residential-scale) systems, electronic meters with digital displays are available at a wholesale price of under $50, which if installed along with the rest of the system should add no more than $100 to the total cost. For three-phase (commercial-scale) systems, there are a variety of meters available to track system performance, with wholesale prices ranging from $200 - $500. For systems over 30 kW, installing these meters is likely to add about 0.25 percent to the cost of the system.

We do not support using built-in inverter displays to monitor system performance for PBI tracking purposes, for several reasons. First, inverter manufacturers have not gone through the process of having these displays calibrated or validated for revenue purposes. Second, there is at least anecdotal evidence of inconsistencies between these displays and revenue-grade meters on PV systems configured with both. Third, revenue-grade metering is universally recognized and accepted as reasonably secure and reliable, which would help with the credibility of a PBI program.

4.3.2. Self-Reporting

Our proposal is that the PBI payment be made annually for five years, based on the customer's self-reporting of electricity generated during each year.

This approach has several advantages. First and perhaps most important, it is inexpensive to administer. Customers would be reminded – by e-mail, phone, or postal mail – of the need to check their meter on or near the anniversary date of its operation (based on the date of inspection of the system, which already is reported to the CEC and CPUC as part of the rebate application process). Other options include individual meter reading by qualified personnel, or the use of remote meter reading technologies. Either alternative would be substantially more expensive.

The second advantage is that it is simple to validate the self-reported figures, within a relatively modest range. Solar radiation levels are much more uniform for a given geographic area, than, for example, wind resources. This makes the output for a well-sited PV system easier to predict. In fact, there are a variety of models – including PVWATTS and the Clean Power Estimator™, that are frequently used for precisely this purpose. Self-reported figures can be quickly and easily checked against such a model. If a self-reported figure substantially exceeds the predicted output for the system, the customer can be contacted to double-check the figure, and if a discrepancy remains then an on-site audit can be conducted to verify or correct the figure. If a self-reported figure falls substantially short of the predicted output, then again customers can be contacted to double-check the figures, and potentially to have the system inspected for potential wiring or other malfunctions.

4.3.3. Auditing

Self-reporting of system performance also can be validated with an auditing effort that inspects a small percentage of the systems and verifies the self-reported performance figures. Auditing only a small percentage of the systems would provide an effective deterrent against misreporting, since the consequences would likely include revocation of PBI payments and, in extreme cases, prosecution for fraud.

In 2002, the CEC buydown program had about 8,000 participants. Assuming the same level of activity in future years, an audit of 5 percent of new systems would involve 400 visits per year. Even assuming an auditor could only visit two systems in a day (which seems conservative), the annual audits could be performed by one person working full-time. Doubling the number of audits to spot-check older systems would require two full-time positions. These costs are minimal in the context of the overall program expenditures.

5. THE PERFORMANCE-BASED INCENTIVE MODEL

We developed an Excel spreadsheet model that produces, from a set of assumptions, a recommended incentive level for a per-kilowatt hour PBI.

5.1. Inputs and Outputs

Inputs to the model include:

- Capacity-Based Incentive (CBI) currently in place, or otherwise to be used for comparison purposes ($/Watt - CEC)
- CBI equivalent to be used in the PBI calculation ($/Watt - CEC)
- CBI portion of the new incentive program (allowing a split incentive structure, or set to zero for a 'pure' PBI) ($/Watt-CEC)
- Number of years over which PBI payments will be made (Years)
- Net discount rate used for future year payments (%)
- Whether payments are front-loaded or not (Yes/No)
- System size (kW - CEC)
- Expected capacity factor (%)

Outputs from the model include:

- Annual Expected Production (kWh)
- Annual Expected Production per kW of Capacity (kWh/kW)
- PBI - CBI Portion (Total $)
- PBI - PBI Payment per kWh (per Year)
- PBI - PBI Portion ($ per Year)
- PBI Portion Total (Total $)
- Total Payment - CBI Portion & PBI Portion (Total $)
- Net Present Value of Total PBI Payments (Total $)

5.2. Baseline Assumptions

Our baseline assumptions for the model were as follows:

- A current CBI of $3.10 per Watt
- A PBI that is equivalent to a CBI of $4.00 per Watt
- A zero CBI portion in the PBI program (e.g. a 'pure' PBI)
- A five-year stream of payments
- A net discount rate of 4 percent per year
- No front-loading of payments
- A 4 kW system size
- An 18% capacity factor

5.3. Results From the Baseline Analysis

The baseline analysis results revealed that the financial equivalent of a $4.00 per Watt capacity-based incentive, under the assumptions described above, would require a first-year performance incentive payment of $0.51 per kilowatt-hour, escalating in the following years to $0.59 in Year 5. On a nominal (non-discounted) basis, this provides a stream of payments of $7,332 over five years. At a net discount rate of 4%, the net present value of this stream of payments is $16,000.

5.4. Alternative Scenarios

Although the model allows for an effectively infinite range of scenarios, we will briefly note a few alternative results. Except as indicated, all assumptions remain the same as the baseline analysis.

5.4.1. Decreasing the Capacity-Based Incentive Equivalent

Decreasing the capacity-based incentive (CBI) equivalent that the PBI is intended to match, from $4.00 to $3.10 per Watt (the current CEC incentive level for residential systems), requires a first-year PBI payment of $0.39 per kilowatt-hour and a nominal stream of payments totaling $13,432.

5.4.2. Using a 'Hybrid' CBI and PBI Combination

A hybrid approach that uses a reduced CBI of $2.00 per Watt in combination with a PBI equivalent of $2.00 per Watt (rather than a 'pure' PBI) results in a first-year PBI payment of $0.25 per kilowatt-hour and a nominal stream of payments totaling $8,666 (in addition to the CBI rebate of $8,000).

5.4.3. 'Front Loading' the PBI Payments

Payments to the system owner can be front-loaded to provide a more immediate return on investment. Paying 40%, 30%, 15%, 10% and 5% of the total payments in Years 1 to 5 respectively results in a PBI payment of $1.01, $0.79, $0.41, $0.29, and $0.15 per kilowatt-hour and a total stream of payments of $16,911.

5.5. Observations From the Analysis

The PBI figures from the baseline analysis represent a price per kilowatt-hour that is roughly two to four times prevailing retail residential rates, depending on which top-tier rate the customer reaches, which is usage-dependent. Interestingly, the PBI figures from the baseline analysis are roughly comparable to those paid in Germany under the 'feed law' – although in Germany the payments are made for ten years, fully twice as long. This means a PBI in California is effectively less costly than in Germany, mostly because solar radiation is considerably stronger, and average utility rates are higher, in California.

The hybrid option, combining a reduced capacity-based incentive with a performance-based payment, might be attractive as a transitional approach, particularly because of the difficulty of accurately predicting how the PV industry and its customers will respond to the loss of the capacity-based rebate to which they have become accustomed. However, a hybrid approach would impose a substantially greater administrative burden on the agencies responsible for program implementation.

6. CONCLUSIONS

Existing capacity-based incentive payments have long been criticized as providing the wrong incentive. PV systems installed under California's existing capacity-based rebate program have been found to suffer from problems related to poor siting, bad design, and improper installation. Shifting to a performance-based incentive program may help to remedy these problems by rewarding system owners only for the electricity actually produced, creating an incentive for system owners (and their contractors) to be more attentive to proper siting, design, and installation of systems.

7. ACKNOWLEDGMENTS

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8. REFERENCES

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