SOLAR 2011: WHY BOTHER? CAPTURING THE VALUE OF NET METERING IN COMPETITIVE CHOICE MARKETS

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ABSTRACT

In regulated electricity markets, net metering can be a relatively straightforward transaction between a utility and an electric customer. The introduction of retail choice and competitive suppliers, however, present complicating factors which are not widely appreciated. This paper follows the authors' prior work describing the operation of net metering in retail choice states to explore what net metered distributed generation means to competitive suppliers. It begins by reviewing the mechanics of net metering operation in retail choice markets. It continues by describing how behind-the-meter generation is valued in wholesale electricity markets, whether these practices provide value for competitive suppliers, and how distributed generation may fit with a competitive business model. The paper follows up with further considerations regarding marketing and customer sign up, power purchase agreements and rate structure. It concludes with recommendations for ways to more fully integrate customer-sited distributed generation, net metering, and retail choice.

1. INTRODUCTION

Net metering has long been identified as one of the most important, least-cost policies by which owners of solar or other renewable systems may recoup their energy investment and ultimately save money on electricity purchases. Similarly, the potential for consumer electricity cost savings is typically among the chief justifications for opening electricity markets to retail competition.

Due to the diverse and complex nature of retail choice markets and the frequent lack of statutory and regulatory clarity on how net metering and competitive supply options operate in conjunction with one another, net metering in restructured states has traditionally not been well understood in the industry. In a prior research report published in December 2010, titled, *The Intersection of Net Metering and Retail Choice, An overview of policy, practice and issues*, the authors identified the basic net metering requirements placed on competitive suppliers and the crediting mechanisms between competitive supplier, utility, and customer in each of the 14 states which offer retail choice.[1]

The "retail" transaction involving the customer-generator, typically defined to some extent by state net metering laws, is only a part of the picture. This paper builds on the December 2010 study to describe in greater detail the implications of distributed generation (DG) for competitive electricity suppliers.

2. BACKGROUND ON RETAIL CHOICE AND NET METERING

2.1 Retail Choice

The electric industry is essentially a sum of its component pieces: production, transmission, distribution and customer service. Traditional, vertically integrated electric companies incorporate all four of these elements. As a result of restructuring in 14 states, plus the District of Columbia[2]

beginning in the early 1990's, these functions are performed by separate companies, comprised of : competitive suppliers that provide energy, distribution utilities that deliver the energy, and end-user customers, all operating in a functioning, competitive energy market.

Competition was introduced into the electricity market to encourage greater efficiencies on the grid and reduced costs to the end user. [3] Many researchers argue, however, that competitive markets do not encourage renewable energy investments due to their inherent purpose of finding the lowest-cost electricity for customers.[4] Others argue that "competitive electricity markets provide the lowest possible cost resources, improve reliability, and are good for the environment because they reduce pollution through improved operations, more efficient generating plants, greater demand responsiveness, and market entry by renewable resources."[5] Despite over a decade of experience with competitive markets, the jury is still out on whether competitive markets encourage or discourage renewable energy investments, in aggregate.

2.2 Net Metering and Competitive Suppliers

As detailed in the *Intersection of Net Metering and Retail Choice* report, five states require competitive suppliers to offer net metering, seven states explicitly do not require them to offer net metering and the remaining four states' rules are silent on the issue. Regulatory silence is a troublesome because it creates uncertainty for all involved. However, even in states which place a net metering obligation on competitive suppliers, the enforcement of such a requirement is problematic. After all, competitive suppliers choose their own customers, which leads to questions about how an obligation to provide service to net metered customers could be enforced. Ultimately, it may rest on the willingness of competitive suppliers to offer net metering service or otherwise serve DG customers out of simple good faith, or because doing so is economically advantageous.

So why would competitive suppliers want to have a DG customer? At first glance, it seems as though serving net metering customers is diametrically opposed to goals of competitive suppliers (i.e., the sale of electricity) because customer generation reduces purchases from the supplier. While this argument does have merit, we believe that it is overly simplistic and that there are in fact a variety of other incentives and disincentives involved. The following sections describe both the energy related and non-energy related considerations of DG from the perspective of a competitive supplier.

3. CUSTOMER-SITED GENERATION AND WHOLESALE ELECTRICITY MARKETS

3.1. Overview

On a real time basis, the energy production of a distributed generation customer can be separated into two distinct quantities: the energy produced and used immediately on-site, and the energy exported to the electric grid when on-site demand is lower than production. The first quantity is the functional equivalent of energy conservation or energy efficiency (i.e., forgone grid consumption). The second is akin to wholesale energy production, albeit at much smaller scale than that typically found in the electricity industry.

From the perspective of the customer, the value of the first quantity is equivalent to the retail value of the volumetric energy charges paid by the customer. The value of the second quantity is generally determined by state net metering laws (or lack thereof). From the perspective of an electricity supplier providing service to a distributed generation customer, the value of both quantities is determined by the wholesale energy market and how it operates.

3.2 Wholesale Market Settlement

Market settlement is the process by which a wholesale market operator (e.g., the Electric Reliability Council of Texas, a.k.a. ERCOT) determines how much a market participant owes or is owed for the provision or use of market services over a specific time period. In terms of energy, the basic idea is that each unit of energy that is put on the grid or pulled off the grid has a specific value according to when it was generated or used. For the purpose of settlement, energy use must be balanced exactly with generation, imports, exports, and losses (i.e., energy in = energy out). The process itself can be exceedingly complicated and the details vary from market to market. However, the following simplified description is useful in understanding where customer-sited systems fit into the larger wholesale electricity picture. This description is based largely on the description of real time energy settlement practices contained in the Pepco Holdings Inc. *Supplier Operating Manual*[6], but similar processes exist in other jurisdictions.

A competitive supplier serving retail customers can be seen as an energy purchaser at the wholesale level. The customers that the supplier services have a demand for energy that varies over the course of each day, and which collectively must be met in real time with an equivalent amount of generation. The supplier therefore has a time-varied *energy obligation* for its collective customers within a given geographic region. Because electricity prices vary significantly over time, for settlement purposes the energy obligation is broken into smaller intervals (e.g., hours or even shorter intervals). Using hours as the interval, a supplier has an hourly energy obligation for each of the 24 hours of the day.

On a daily basis, a supplier's hourly energy obligation for a given region is arrived at using a combination of actual metered data and estimates of customer usage. The calculation process is typically performed by a utility for customers and their suppliers within its service territory. For customers with interval meters which are read daily, actual values would be used. For most customers however, meter reading does not take place on a daily basis, so hourly loads are estimated using load profiles. A customer load profile is a representation of how the electricity use of a given type of customer is expected to vary over time, adjusted for a variety of potential factors (e.g., weather, location, etc.). On a daily basis, each customer is assigned an hourly load value based on actual or estimated hourly use. This value is then typically adjusted to incorporate expected energy losses in the electric transmission and distribution grid. The hourly values are summed together to arrive at a preliminary estimate of a supplier's hourly energy obligation for its collective customers. This is "energy-out" part of the equation.

The "energy-in" part of the equation for a given area is measured by the meters installed at all points from which energy can enter or leave the system. The energy-in and energy-out values must match for settlement purposes, but in reality the sum of all hourly supplier energy obligations for a geographic area (i.e., a utility service area) will not match the total load that the market operator calculates for that area based on metered generation, imports, and exports. The difference could be positive or negative and is often referred to as unaccounted-for energy (UFE).

Accounting procedures for UFE vary, but in this case an adjustment is applied across all hourly supplier obligations within a geographic area on a pro-rated basis. In other words, a supplier with 5% of the total load from 10 AM – 11 AM would be allocated 5% of the UFE calculated (positive or negative) for 10 AM – 11 AM for that day. A supplier's "bill" for real-time energy purchases is based upon this hourly energy obligation as well as a variety of other factors (e.g., energy purchases from the day-ahead market), price at some variation of the hourly market price.

The aggregation process described above takes place on a daily basis. A further reconciliation is necessary to incorporate actual meter data from customers whose meters are read on a monthly rather than a daily basis. The methodology is essentially the same; actual hourly metered values are used if they are available and load profiles are used to estimate hourly load if this is not the case.

3.3 Potential Value of Customer-Sited Generation

It is indisputable that just as generation from a typical centralized power station has value, so does the much smaller amount produced by a customer-sited energy system. However, in an industry dominated by large central station power plants, small customer-sited energy generation is in many cases relegated to being an afterthought (or perhaps a never thought). The immediate consequence of this is that customer-sited generation may be left out of bulk electric power market protocols and ultimately not valued on equal footing with more conventional wholesale power generation. Under these circumstances, whatever the potential, it remains unrealized.

An overview of the ERCOT market settlement procedures is instructive in understanding where potential value lies and how it can be realized. In ERCOT settlement procedures, the use of customer-sited solar in distributed applications can benefit suppliers in two ways. The first way a competitive supplier in ERCOT can benefit from serving a solar customer is due to the fact that all other things being equal, solar customers tend to have lower energy demands during the middle part of the day because this is the time when a solar system produces the most energy.

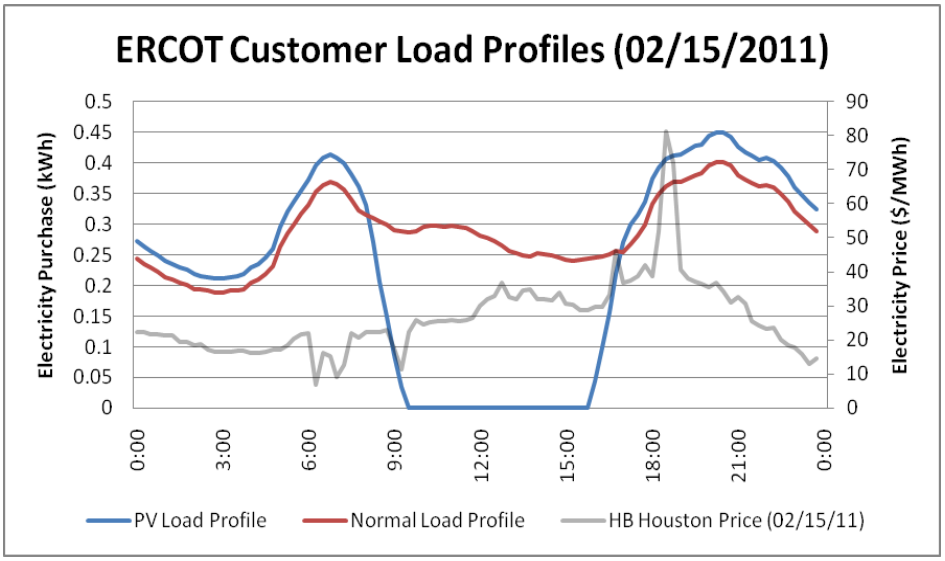

Fig. 1: ERCOT Customer Load Profiles for 2/15/2011.

The ERCOT settlement process recognizes that customers equipped with DG systems have different electricity purchase patterns than non-DG customers, and that different types of DG system (e.g., solar, wind, etc.) have different characteristics which also affect the temporal variation in customer electricity demand. This is illustrated by the use of solar specific load profiles for customer loads that are not equipped with interval meters.[7] Figure 1 shows a graphical representation of the back-casted (i.e., actual) load profiles for February 15, 2011 which would apply to a residential electricity customer in the coastal region of ERCOT with a high winter demand, varied by whether or not the customer site is equipped with a PV system.[8] The graphic also includes representative electricity prices for the same time period and location.[9] February 15 was chosen simply because load profile and price data for that date were easily obtainable.

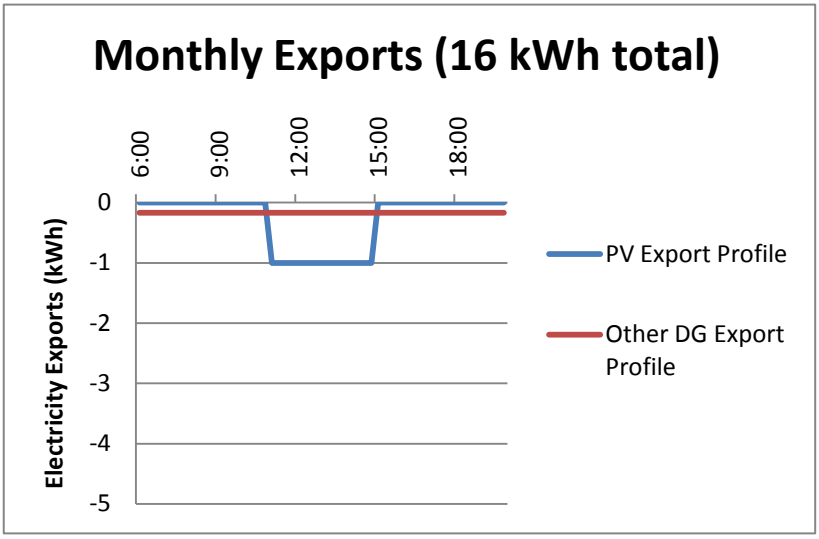

Fig. 2: Monthly Exports (16 kWh total).

The PV customer's load profile shows an obvious dip during the middle part of the day where the customer requires a lower amount of electricity from the grid due to the electricity produced by the PV system. The potential benefit to the supplier depends on how wholesale electricity prices vary over time. If prices are comparatively higher during time periods when the PV system is producing significant amounts of energy (i.e., lowering grid purchases), the average cost the supplier bears for serving this customer will be lower than for an otherwise similar non-PV customer.

The second way a supplier may benefit from serving a PV customer is based on the value of the electricity exported by the system. Figure 1 shows that for a significant period of time throughout the day the customer has a load of zero, or less as the case may be, though the profile is not actually permitted to go negative. ERCOT uses a separate methodology to account for electricity exports. As illustrated in Figure 2, ERCOT addresses the value of exported energy from non-interval-metered customers by measuring the volume of gross exports for a billing period and evenly distributing it among the 16 pricing intervals which define the daily period from 11 AM to 3 PM. This exported energy is subtracted from the supplier's load through the aggregation and settlement process. For other distributed generation customers who are not on interval meters, the exports are applied evenly to the supplier's load across all intervals.[10]

Again, the ultimate benefit to the supplier depends on wholesale electricity prices for the period in question, as well as the level of compensation paid to the customer for this exported energy (if any).

The reader should also note that while the processes described above are specific to profiled customer loads, the effect would be similar for customers with interval meters. Indeed, the use of interval meters which can accurately collect time-differentiated data on customer imports and exports essentially places the customer-sited systems on a similar playing field to traditional wholesale generators in the energy value arena. The use of a solar load profile in ERCOT, while interesting, is essentially a second-best option if the goal is to accurately value the energy produced by customer-sited energy systems at the wholesale level.

3.4 Settlement and Value Issues

While the ERCOT example provides some insight into how customers-sited energy production *could* be valued, in practice the ERCOT system is unique, both in the use of solar load profiles, and in providing a well-defined system for valuing generation in excess of on-site needs. In other wholesale electricity markets the protocols are frequently unclear as to the place of customer-sited generation. As a result, utilities which perform the load aggregation and summing processes for settlement are seemingly left to their own devices, and our research indicates that treatment varies by utility.

To the authors' knowledge, outside of ERCOT there are no examples of customer load profiles specific to customer-sited generation for use in energy settlement. In this area, the picture is fairly clear. Utilities publish information on customer load profiles and, due to its importance in the settlement process, such information is typically prominently displayed in the supplier information section of a utility's web site.

Treatment of net excess generation or, in effect, negative load for a given time period, is often harder to ascertain. Despite extensive searching through available documentation (largely standard utility-supplier agreements and utility published supplier manuals), the authors were only able to identify two examples where the issue of excess generation by net metered customers is specifically addressed in the context of load balancing and settlement (Bangor Hydro and Central Maine Power). Several potential scenarios exist depending on utility practices and the information available through actual meter readings.

Scenario 1: Negative load values on an interval or monthly metered basis are interpreted as errors and are assigned zero values in the load aggregation process. This practice results in customer energy exports being classified as UFE (or an equivalent), which effectively lowers the hourly energy obligations of *all suppliers* with hourly energy obligations in a geographic region during a given time period.

EXAMPLE: *National Grid in Rhode Island*. Net metering proceedings in Rhode Island which took place in 2008 suggest that that this scenario applies (at least at this time) for suppliers providing service to net metered customers in National Grid's service territory. National Grid's response to a Rhode Island Public Utilities Commission data request describes an outcome where customer exports reduce supplier settlement obligations for National Grid's territory as a whole rather than for a specific supplier of a net metered customer.[11]

Scenario 2: Negative load values on a monthly metered basis are processed as a reduction in a supplier's hourly energy obligation. For non-interval metered customers, in the absence of a specific methodology for "profiling" excess customer generation, the excess would be applied uniformly across all hourly periods.

EXAMPLE: *Central Maine Power*. The utility addresses net metered customers in standard utility supplier agreements.[12] While these documents do not explain exactly how negative customer loads are addressed, Central Maine Power indicates that negative customer load is expressed as a reduction in supplier hourly energy obligation evenly distributed across all hourly periods for which a supplier's energy obligation is calculated. The utility does not have any net metered customers on interval meters. [13] Notably, the even allocation method is also used for customers in ERCOT that are equipped with other forms of customer-sited generation (e.g., wind) and are not on interval meters.

Scenario 3: Negative load values on an interval-metered basis are applied as a reduction in supplier load for the time period during which they took place.

EXAMPLE: *Pepco, possibly other Mid-Atlantic utilities*. Comments made by Washington Gas Energy Services during recent net metering rulemaking proceedings in Maryland suggest that several utilities support this methodology, but it remains unclear if, and how widely, it is being implemented. The comments do not address an equivalent accounting procedure for non-interval metered customers.[14] Pepco personnel indicate that hourly supplier loads reported to the PJM are reduced for negative customer load up to the zero point for negative meter readings of interval customers but that PJM does not accept negative values for hourly energy obligations. Non-interval negative loads are assigned zero values so they do not reduce supplier hourly energy obligations, effectively becoming UFE.[15]

These examples highlight practices which could prevent a supplier from realizing value from customer energy exports, or lessen that value. The use of non-interval meters is likely to result in any exports being applied evenly across all time intervals. The value that photovoltaic systems add by producing energy during day time hours when electricity is typically more valuable is lost under these circumstances. Moreover, as indicated in Scenario 3, it could be that non-interval metered exports are not reflected as reductions in supplier hourly energy obligations.

Interestingly however, if exports do accrue to the grid as a whole instead of to a specific supplier, it would likely be to the supplier's advantage for the exports to come from a non-interval-metered customer. A recent analysis based on Maryland customer load and insolation data indicates that the monthly net excess generation zero point (i.e., no months with monthly negative load) is associated with average annual system energy production sufficient to cover 65% of residential consumption and 72% of commercial consumption (referred to as the *coverage* ratio). On an hourly basis though, the report suggests that customers with a coverage ratio as low as 20% will likely have some hours of net excess generation.[16]

A further possibility is that the supplier's total hourly load obligation (the aggregate of all its customers) could be negative. The likelihood of this seems exceedingly small since net metered customers are a small part of the electricity consumer customer base (competitive or default), and even for systems with high coverage ratios, on an hourly basis the net excess generation from these customers will only be a fraction of the actual energy produced by the system. This would be balanced by positive energy usage at a higher rate per customer over a much larger customer base. Unlikely however, does not mean impossible (e.g., a supplier with a single large industrial customer), and as described in the Scenario 3 example, such negative values may not be accounted for in the settlement process.

4. OTHER IMPLICATIONS OF HAVING DG CUSTOMERS

In addition to the treatment of DG in wholesale load settlement, there are also other considerations for a competitive supplier as it contemplates serving a DG customer. The following section describes several of these issues.

4.1 The Sales Reduction Disincentive

Serving DG customers presents an obvious quandary for competitive suppliers. How is a supplier to make money selling energy if its customers are supplying their own needs, and upon occasion, producing more than they need and even receiving compensation for this excess? The disincentive is not insignificant, but we think it is likely less significant than it initially appears to be.

For one, customers who will be purchasing little or no energy are not likely to be in the competitive supply market in the first place. From the customer perspective, there simply is not much point to pursuing competitive supply options if grid electricity purchases are minimal anyway. Following this line of thought, the group of DG customers who remain potential competitive supply customers must still have significant energy costs. If such customers see value in exercising their retail choice option, it seems as though there must also be value in providing them with energy service.

The supplier's dilemma does however include at least one other element: opportunity cost. Does pursuing a "lower value" DG customer prevent or inhibit a supplier from signing up more lucrative customers? It is reasonable to believe that there is at least some cost. After all, marketing, sales, and negotiation take staff time and resources, which would then be less available for other potential customers. If this cost is greater than the money to be made on sales to the DG customer, the supplier has little reason to offer service. The magnitude of this concern is not clear to the authors at this time.

4.2 Marketing and Increased Customer Sign-up

From discussions with competitive suppliers, the marketing value of "green options" may be one of the most valuable aspects to a competitive supplier. The ability to market their services to a customer that may or may not install DG, but who wants to keep the option open, essentially expands the pool of potential customers available to the supplier. All other things being equal a customer who is interested in solar is more likely to sign up with a competitive supplier that provides an option for customer-sited DG, rather than one that does not allow it. For a supplier that does not offer net metering service, the increasing prevalence of customer-sited energy generation represents a diminishing pool of potential customers.

Competitive suppliers usually "lock-in" customers with contracts of varying length. Contract termination penalties, in addition to the burden associated with investigating and choosing another supplier may discourage a customer from switching suppliers frequently. Thus, the benefit to a supplier is perhaps two-fold. The supplier has a new customer for the immediate term of the contract, but it has also has the advantage of a longer term relationship in the form of contract renewals, provided of course that the customer remains happy with the service and terms being offered.

To build upon the prior section, the appropriate comparison is not between having a DG customer and having a customer with "normal" electricity use levels (normal sales vs. lower sales) but between having a DG customer and not having a customer at all (lower sales vs. no sales). As evidenced by the prevalence of "green" supply offers, it is also clear that a well-established market for environmentally conscious energy purchases now exists.[17] In some circles distributed renewable generation is considered even "greener" than other forms of renewable energy. A proven record of supporting distributed generation may therefore have additional marketing value beyond customers who have seriously considered DG options.

4.3. Business Diversification through Power Purchase Agreements

The third-party power purchase agreement (PPA) model has become increasingly prevalent in the solar industry during the last several years. Under the PPA model, the service provider owns a PV system on the customer's property and sells that customer the energy from the system for a set contract term (often 10 years or longer). The solar energy sales allow the provider to recoup their investment over time and make a guaranteed return on that investment. The customer, on the other hand, does not have to bear the burden of upfront system costs and generally does not have to worry about the operations and maintenance of the system. While now common in the solar industry, the model has appeared more recently in a handful of service offerings from energy service providers not specifically oriented around solar energy (e.g., Con Ed Solutions, Constellation New Energy, Washington Gas and Energy Services). The competitive suppliers offering this service have added a variation to the model by also offering commodity energy service for the balance of on-site energy needs.

There are several interesting results of this arrangement. For one, it eliminates the effects of customer-sited distributed generation on energy sales to the customer, and from the perspective of the supplier, circumvents the issue of offering net metering service to the customer. The existence of the

long-term PPA also creates a firm long-term relationship between the supplier and the customer, potentially increasing opportunities for the provision of other services (e.g., commodity energy service).

A further implication is that owning a customer-sited solar system potentially increases a supplier's flexibility in meeting mandatory renewable portfolio standard (RPS) obligations. If the supplier owns the solar RECs (which it typically would), it could use them to meet the RPS obligations it carries for its other retail sales, or it could sell to other parties with RPS obligations. The potential benefit to the supplier in this area is to shield it from, or position it to take advantage of, price volatility in solar REC markets, while also improving its ability to plan for meeting its RPS obligations far into the future.

4.4. Service Costs

The administrative and billing costs associated with net metering have recently been studied by several state public utilities commissions, including California and New Jersey.[18] These and other studies have shown that utilities use different formulas for assessing net metering costs, and while the overall cost is minimal compared to other utility programs, it is not zero. While not all of these costs are a concern for competitive suppliers (e.g., forgone distribution revenues), some are potentially applicable.

A supplier may bear costs associated with customer compensation for net excess generation which it is unable to recoup (see Section 3 for details).Moreover, a supplier may bear costs for billing and other administrative procedures if it operates a separate billing system from the utility. There is also the possibility that a lack of experience with DG customers, or lack of information on the patterns of DG customer electricity usage could lead a supplier to make sub-optimal decisions in arranging energy supply for a DG customer.[19] Costs which are minimal to a utility may be more significant to an individual supplier operating on a significantly smaller scale.

5. DISCUSSION AND RECOMMENDATIONS

As described in Section 3, inconsistencies exist in how wholesale electricity markets address distributed generation. Above the somewhat technical issues looms a fundamental question of whether such imperfections are significant enough to merit the time, effort, and expense of devising remedial measures. The relative need for change is a matter of perspective.

From the perspective of the bulk electricity markets as a whole, one could easily conclude that it is of minimal importance due to the small scale of customer energy exports relative to wholesale energy generation. Why quibble over a few dollars when millions change hands every day?

An opposing perspective however, is that one of the guiding purposes behind competition is to create an environment where electricity is priced based on its value at any point in time. If this is truly the goal, then systems should be designed to account for the added complexity of customer-sited generation to the extent it is possible to do so. Moreover, with the prevalence of state net metering laws and state renewable portfolio standards which support customer-sited generation, the scale of the issue itself is destined to grow over time.

Yet another perspective is that of the individual supplier. A supplier in any given state is operating at a much smaller scale than the system as a whole, so each transaction has a somewhat greater importance. A final perspective is that of the distributed generation customer who would presumably want to be able to participate in both retail choice and net metering if they so choose. Yet defining the true character of a state-induced net metering "obligation" for competitive suppliers can be difficult and such requirements ultimately may rest on tenuous ground. Assuming that a net metering requirement can be enforced, the supplier bears a cost (i.e., reduced purchases, customer compensation) without being able to realize some of the potential benefits of having such a customer (i.e., lower overall energy costs). The alternative to coercion is to present a supplier with circumstances which support a decision to voluntarily serve DG customers.

Wholesale market treatment of distributed generation is part of this equation, although it is certainly not the only consideration. We have described a series of factors which may influence supplier decisions, although a more quantitative evaluation may be in order for decision-making purposes. It is, however, obvious that some suppliers see potential in DG-based business models, even if some of the appeal seems to rest in avoiding the issue of net metering altogether. The somewhat different approach of using net metering as a marketing tool is not widely apparent, but our analysis of the costs and benefits suggests to us that it has greater promise than is currently recognized.

Improved protocols for addressing customer-sited DG in wholesale markets may be a large part of the solution. Allowing suppliers to realize tangible energy cost benefits from DG customers would almost certainly affect how they view DG customers as a whole and how they market their services. Enhanced metering systems with interval data recording capability will likely be part of this, albeit costly. A good middle ground between the status quo and a fully revamped metering infrastructure could be the use of load profiling and accounting procedures such as those currently used in ERCOT. While this strategy undoubtedly would

involve a certain amount of time and expense as well, it seems as though the relatively simple ERCOT model could serve as a good example.

In this regard, simplicity is paramount. The issue of wholesale valuation of net metered energy is at this point relatively minor when seen in the context of the wholesale electricity markets in aggregate. Elaborate mechanisms are not needed to improve on the current state of affairs. Moreover, ERCOT enjoys the advantage operating only within the confines of a single state. It stands to reason that any uniform treatment would need to be simple in order to accommodate a multitude of possible state and regional circumstances. The issue will certainly bear watching in the coming years as more distributed generation systems are installed among competitive choice customers. Competitive suppliers would be wise to take note of this evolving marketplace and consider ways to evolve their own businesses to capitalize on the opportunities it presents.

6. ACKNOWLEDGEMENTS

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[1] See http://irecusa.org/wp-content/uploads/2010/12/FINAL-Intersection-of-Retail-Choice-and-Net-Metering-Report.docx.pdf

[2] California, Connecticut, Delaware, Illinois, Maine, Maryland, Massachusetts, Michigan, New Hampshire, New Jersey, New York, Ohio, Pennsylvania, Rhode Island, Texas and Washington D.C.

[3] Electricity Journal, Fereidoon P. Sioshansi, *Competitive Electricity Markets: Questions Remain about Design, Implementation, Performance*

[4] See http://www.erb.umich.edu/News-and-Events/Conferences/arcs-09papers/Kim_deregulation_renewable.pdf

[5] See http://www.epga.org/EPGA.PA.11-6-07rev.doc

[6] Pepco Holdings Inc., "Supplier Operating Manual". See http://www.pepcoholdings.com/_res/documents/PHIoperationsmanual2007.pdf

[7] Electric Reliability Council of Texas (ERCOT). "Load Profiling Guide" http://www.ercot.com/mktrules/guides/loadprofiling/current

[8] Electric Reliability Council of Texas (ERCOT). "Backcasted Load Profiles Extract". http://www.ercot.com/mktinfo/loadprofile/

[9] Electric Reliability Council of Texas (ERCOT). "Real Time Settlement Point Prices Display". (Accessed 02/18/2011). http://www.ercot.com/content/cdr/html/real_time_spp

[10] Electric Reliability Council of Texas (ERCOT). "Current Protocols – Zonal, Section 11: Data Acquisition and Aggregation". http://www.ercot.com/mktrules/protocols/current

[11] National Grid. Rhode Island Public Utilities Commission Docket 3904. "Response to PUC's 1st Set of Data Requests". January 18, 2008. http://www.ripuc.org/eventsactions/docket/3904-NGrid-DR-PUC(1-18-08).pdf

[12] Central Maine Power. "Competitive Electricity Provider Service Agreement – Exhibit A". http://www.cmpco.com/SuppliersAndPartners/MainesElectricityMarket/CompProviderService/default.html

[13] Clary, Susan. Central Maine Power. Personal Communication. February 25, 2011.

[14] Washington Gas Energy Services. Maryland Public Service Commission Docket RM 41."Comments". August 9, 2010. http://webapp.psc.state.md.us/Intranet/AdminDocket/NewIndex3_VOpenFile.cfm?ServerFilePath=C%3A%5CAdminDocket%5CRuleMaking%5CRM41%5C010%2Epdf

[15] Kevin Campbell. Pepco. Personal Communication. March 3, 2011.

[16] Maryland Energy Administration. Maryland Public Service Commission Docket RM 41."Comments". August 9, 2010. http://webapp.psc.state.md.us/Intranet/AdminDocket/NewIndex3_VOpenFile.cfm?ServerFilePath=C%3A%5CAdminDocket%5CRuleMaking%5CRM41%5C009%2Epdf

[17] U.S. DOE, EERE Green Power Network. "Buying Green Power". http://apps3.eere.energy.gov/greenpower/buying/index.shtml

[18] http://www.cpuc.ca.gov/NR/rdonlyres/0F42385A-FDBE-4B76-9AB3-E6AD522DB862/0/nem_combined.pdf and http://www.njcleanenergy.com/renewable-energy/programs/net-metering-and-interconnection

[19] Washington Gas Energy Services. Maryland Public Service Commission Docket RM 41."Comments". August 9, 2010. http://webapp.psc.state.md.us/Intranet/AdminDocket/NewIndex3_VOpenFile.cfm?ServerFilePath=C%3A%5CAdminDocket%5CRuleMaking%5CRM41%5C010%2Epdf