Using Wind Power to Hedge Volatile Electricity Prices for Commercial and Industrial Customers in New York

Executive Summary

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NOTICE

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Executive Summary

Introduction

The introduction of competitive wholesale electricity markets is leading to greater price volatility. Reliance on a single fuel source – natural gas – to meet the vast majority of incremental supply needs on a nationwide basis has the potential to exacerbate this situation.

Wind power generation is increasing in New York, in large part due to aggressive incentive programs developed by the New York State Energy Research and Development Authority (NYSERDA). Wind power projects, however, are capital-intensive and have generally required long-term contracts with credit-worthy power purchasers to attract financing. Questions remain over whether new wind projects in New York will be able to find viable demand for their output.

A key advantage of wind power is that it is free of fuel costs, and it has often been sold through fixed-price power sales contracts to utilities and ESCOs. While this "hedge" value can clearly be provided at the wholesale level, open questions remain over whether and how a wind generator or an ESCO might take advantage of this benefit and sell a renewable electricity product to end-use customers as a long-term hedge with terms and quantities sufficient to support financing. Could a generator or an ESCO design such a green power product? How, and at what cost? Would such products be attractive to end-use customers, and would the marketing of a wind-hedge product significantly increase customer demand for wind power?

This scoping paper addresses these questions from the perspective of commercial and industrial (C&I) customers in New York, wind generators seeking to access markets and financing, and ESCOs or other organizations selling wind power to end-use customers. Our purpose is to assess whether the potential value of wind power as a price hedge for large electricity end-users in New York is substantial enough to warrant more detailed investigation.

As highlighted below, this study concludes that wind-generated electricity can provide important hedging benefits to New York's wholesale electricity markets, but that providing this benefit to individual C&I customers is more challenging. The barriers to using wind as a retail wind hedge can be significant, and suggest that retail wind hedge tools may be most attractive to a limited segment of the C&I market. Nonetheless, our analysis suggests that wind can provide a good, if not perfect, hedge for many C&I customers. While opportunities for retail wind power hedges may not be pervasive, there are certainly niche applications and certain customer types that merit further attention.

This executive summary is intended to provide a concise yet reasonably detailed review of the full report, and is organized as follows. We begin by describing the basics of electricity price volatility, the determinants of that volatility, the disconnect between wholesale price volatility and retail rates, and the interests of C&I customers and wind generators in seeking price stability. We review conventional hedging strategies used at the wholesale and retail levels to provide price stability, and their relative advantages and disadvantages. The advantages of using wind to hedge wholesale and retail electricity price risks are then described, and we identify two transaction structures that might be used to deliver the hedge value of wind power to C&I customers. We also highlight industry experience in using wind power as a hedge in green power product offerings. We then turn to a discussion of six key barriers to the use of wind-generated electricity as a hedge against retail price volatility. We also summarize our quantitative analysis of two of these key barriers, and present results on the overall effectiveness of a wind hedge product. Because this study is intended as a scoping exercise, not a comprehensive literature review or analysis of the issues at hand, we conclude by identifying possible next steps for NYSERDA and future areas of study.

The Basics of Price Volatility

The report begins in Section 2 with an introduction to electricity price volatility, the determinants of that volatility, how wholesale price volatility is reflected in retail electric rates, and the interests of C&I customers and wind generators in seeking price stability.

Price Volatility in Wholesale Electricity Markets. Particularly in emerging competitive wholesale electricity markets such as New York, electricity prices have proven to be especially volatile, subject to rapid and severe price fluctuations on hourly to annual timeframes. The risk of rising prices based on shifts in underlying fundamentals, such as natural gas prices or capacity shortages, can be especially severe, as demonstrated by the California electricity crisis in 2000 and 2001. Such market events can lead to degraded electrical reliability, and to financial distress for electric utilities, competitive energy providers, and end-use customers.

The Determinants of Wholesale Volatility and Rising Prices. Price volatility in wholesale electricity markets is caused by the complex interaction of a number of key factors. These factors are exacerbated by the lack of cost-effective physical storage and the need for real-time delivery of power. The supply-demand balance is perhaps the most critical determinant of wholesale price volatility. Tighter supply leads to higher price and greater potential for price volatility. This balance is dictated by demand fluctuations, installed generation capacity, and plant availability. The incremental operating cost of the marginal generating unit called upon at any point in time will dictate prices in times of sufficient supply, with the plant's fuel costs being a primary driver. Volatility can be exacerbated, however, particularly when available supply gets tight, by transmission congestion, lack of demand response, or the exercise of market power. Finally, environmental compliance costs can influence long-term price trends.

How Wholesale Prices and Volatility Translates to Retail Rates. The degree to which wholesale price volatility is reflected in the electricity prices faced by retail customers is a fundamental factor influencing a customer's need for or interest in price hedging. In monopoly markets characterized by vertically integrated utilities, a traditional goal of utility regulation has been to stabilize retail electricity prices. In restructured markets such as New York, however, retail customers have increasingly been exposed to greater price volatility.

In New York, C&I customers can choose supply from an incumbent utility under regulated rate structures or from an ESCO.

- **ESCO Service:** Under ESCO service, volatility depends on the pricing structure the customer selects. Options typically include wholesale spot market pass-through and fully- (e.g. fixed-price) or partially hedged products. Few customers, however, have switched away from the utility option and take ESCO service.

- **Utility Service:** The exposure of retail customers taking utility service to wholesale price volatility varies by utility service territory, in part because New York's utilities have divested their generating capacity to varying degrees and in part because each utility has a different wholesale procurement strategy. For instance, we find that in the Niagara Mohawk service area, rates are set on an hourly basis, thus exposing default service customers to the full volatility and uncertainty of the wholesale electricity market. In contrast, Con Edison sets generation rates for six months at a time, based on significant short-term hedging, without making the details of its hedging strategy widely available.

Without volatility in retail electric prices, retail electricity consumers have little reason to consider price hedges. As a result, the market opportunity for wind-hedge products (or any retail electric hedge products) is largely limited to the utility service territories in New York where consumers are exposed to significant price volatility, unless customers move to ESCO service with prices based on a wholesale spot market pass-through.

C&I Customers' Interest in Hedging Exposure to Rate Changes. The goal of hedging electricity prices is to reduce a market participant's exposure to price volatility or changes in price trends. Hedges do not reduce prices on average, and typically there are costs associated with putting hedges in place. Where commercial, industrial and institutional customers do face electricity price volatility, a subset of those customers may value a retail price hedge. For instance, price hedging might help end-use customers protect their annual energy budget, stabilize their competitive position in a regional and global market place, and insulate their economic performance from energy price risk. Surveys indicate that many large electricity consumers state a willingness to pay a premium for stable electricity rates. Experience, meanwhile, suggests that in markets where customers have been recently exposed to such volatility, their interest in hedging may become heightened.

Wind Generators' Interest in Long-Term Fixed-Price Contracts. For generators, the value of price hedging is to remove some or all of the uncertainty in the revenue stream on which project lenders and investors rely. Given wind's capital-intensity, substantially fixed cost structure, higher overall costs, and intermittence, the relative importance of locked-in minimum cash flows is magnified. As a result, lenders generally require wind projects to have long-term agreements to sell electricity and/or generation attributes at fixed-prices with credit-worthy parties.

In New York, however, credit-worthy buyers in the wholesale market appear to be scarce. Utilities, seen as credit-worthy by the financial community, are generally not making long-term purchases. Competitive ESCOs rarely have the capitalization to enter financiable long-term contracts. Wholesale intermediaries, meanwhile, rarely enter into long-term, uncovered positions in additional generation without evidence of a strong market and/or short-term sales commitments already in place. With few credit-worthy *wholesale* alternatives, a wind generator could look directly to credit-worthy customers in the *retail* C&I market to provide sufficient cash flow to attract financing through the sale of wind-hedge products..

Conventional Hedging Strategies

Since wind power must compete against conventional means of hedging electricity prices, the value and cost of conventional hedging instruments, as well as their availability to C&I end-users, provides a benchmark for wind as a hedge. Section 3 addresses these issues in depth, starting with a discussion of wholesale hedging strategies, and then turning to retail hedging strategies and the possible cost of those strategies.

Wholesale Electricity Market Hedging Strategies. There are a number of tools available to hedge prices in wholesale electric markets. These include physical hedges, such as ownership of generating assets, forward purchases of energy or other electric commodities (capacity, ancillary services), or options to buy or sell electricity in the future at a specified price. Financial hedging tools are also available, including exchange-traded futures contracts, as well as other derivatives such as financial call and put options and contracts for differences (CFDs). These tools are generally available in large standardized blocks that are ill-suited to all but the largest end-use customers.

Retail Rate Hedging Strategies. C&I customers can use conventional hedging tools to reduce retail rate volatility in three ways:

- *Remain on floating priced utility generation service or switch to spot-price pass-through ESCO service, and separately hedge price with a financial tool such as a CFD.* Remaining on utility service avoids the credit risk associated with entering a long-term hedge with an ESCO, and avoids the need to enter into new electricity contracts. If utility prices do not closely track wholesale spot prices, however, the combination with a financial hedge may not produce the desired results. Whether on utility or ESCO service, the tools available for financial hedging may be traded in sizes larger and/or terms shorter than desired by the customer. Directly entering into financial hedges also requires a significant level of commercial sophistication that may only be available to larger C&I customers.
- *Purchase electricity from an ESCO under a fixed-price contract or a floating price arrangement with caps or collars*. This is the simplest way, and for some customers, perhaps the only conventional way to hedge price risk. ESCOs are well suited to provide standard pricing structures, and can also provide the advantages of one-stop shopping, transparent pricing, access to an ESCO's market knowledge, and availability at desired scale. Potential disadvantages include credit risk associated with the ESCO, and the need to address this risk in contract negotiations, as well as the short duration of most ESCO hedge offerings.
- *Install on-site generation or curtail load.* Under this final approach, the degree of price protection is limited to the times in which it is economic to curtail load or run the generator, so that in many cases such a hedge can be valuable but imperfect.

Cost of Conventional Hedging Approaches. While all forms of hedging bear costs (either direct, opportunity, or both), quantifying the total cost of implementing a conventional electricity hedge is tricky business. Accordingly, we are only able to provide a general discussion of these issues, and some indicative numbers on hedging costs.

Some components of electricity price risk can be hedged directly and independently. For example, natural gas price risk can be hedged through derivatives or fixed-price physical supply contracts. Bolinger et al. (2002) estimate the cost of hedging fuel price risk (i.e., the natural gas component of electricity price risk) at the *wholesale* level to be on the order of 0.5¢/kWh. Similarly, if generation supply sources are located in a different LBMP pricing zone than the load, or if financial hedges are indexed to prices in a different zone, then the potential for transmission congestion becomes an additional electricity price risk. Transmission congestion contracts can be purchased at auction or in a secondary market as a hedge on inter-zone transmission.

Other determinants of wholesale price volatility, such as those caused by a supply-demand imbalance, cannot readily be hedged independently (of fuel price or other risks). One must either hedge all price risks (i.e., including fuel price risk) collectively through physical electricity forwards or financial hedges, or alternatively, hedge many non-fuel risks collectively through a "tolling agreement." Lack of demand response, and market power, largely fall within the same category. Finally, the costs of complying with *future* environmental regulations cannot be easily hedged through conventional means, both because the exact nature of the risk cannot be known in advance, and because most generation sources have limited means to mitigate their impacts.

One additional component of hedging costs common to all hedges, whether physical or financial, is transaction costs. Generally speaking, using financial markets to hedge for longer than a few years can potentially result in significant transaction costs and the more illiquid and inefficient the market, the higher the transaction costs will be. Electricity markets are thinly traded beyond a few years. An advantage of using wind power as a hedge, therefore, is that it reduces (if not eliminates) the need to incur wide bid/offer spreads and large transaction costs on conventional futures or forward hedge products (though, of course, the wind product itself may have its own transaction costs).

Providing a Retail Wind Hedge – The Basics

Section 4 builds upon the background on volatility and conventional hedging instruments by evaluating the merits of using wind power as a retail rate hedge, highlighting two distinct structures to a wind-hedge product, and summarizing industry experience with wind-hedge products to date.

The Price Stability Benefits of Wind Power at Wholesale and Retail. The fact that wind power can hedge *wholesale* electricity rates is relatively well established. The characteristics of wind that provide these price hedge benefits include the lack of fuel costs, limited exposure to future environmental compliance costs, modularity and short lead-time. These characteristics ensure that wind generation can provide value in moderating electricity price levels and volatility relative to physical contracts backed by natural gas combined cycle capacity, for example.

Though the ability to pass on the *wholesale* price stability benefits of wind power to specific C&I customers at *retail* is the subject of much additional discussion in this report, it is first important to establish the fact that there are certain advantages to wind-hedge products for C&I customers. First, because wind projects require long-term contracts for financing, wind generators can offer longer-term hedges than are typically available through conventional means. Even where long-term conventional hedges are available, these markets are often thinly traded, so high transactions costs create a higher benchmark against which a wind power hedge would be measured. In addition, as a physical hedge backed by a sizable fixed asset with low operating costs and few long-term risks, a wind hedge may be less susceptible to credit risk concerns than some of the conventional hedge strategies. Finally, the hedge value may provide added value to a C&I customer considering a green power purchase.

From the wind generator's perspective, meanwhile, selling a wind hedge may satisfy the lender's requirements for a long-term, stable revenue stream. In addition, the hedge value provides the potential for an incremental revenue stream. Three products - commodity energy supply, renewable energy attributes, and a financial hedge - could conceivably be sold, either independently or collectively.

Wind Hedge Transaction Structures. We find that the hedge-value of wind power can be delivered to end-use customers through two classes of transaction structures: bundled renewable electricity service, or financial contracts-for-differences.

- **Bundled renewable electricity service** entails the supply of a standard electricity product by an ESCO. The ESCO would presumably purchase wind energy at a fixed price, and then offer its customers a wind-based retail electricity product at a fixed or stable price.

- **Financial contracts-for-differences** would represent a purely financial product that may be able to provide similar stability to a bundled electric supply product. Under this arrangement, the customer would continue to receive electricity supply from the default service provider or from a traditional ESCO. The price of this supply would not be fixed, but would instead be indexed to the local LBMP. A separate financial contracts-for-difference (CFD) would be signed with a wind power generator or intermediary. As with a conventional CFD, a wind-based CFD is a financial fixed-for-floating swap transaction between a wind generator (or intermediary) and an end-user. The variable payment equals the difference between the chosen spot market index and a negotiated "strike price." When the strike price exceeds the index, the hedger pays the wind plant the difference, and when the index price exceeds the strike price, the wind plant pays the hedger the difference.[1] Such a CFD is a perfect hedge for the wind generator if the generator sells energy into the same spot market to which the CFD is indexed. If wind production is low (high) at times when the index price exceeds (falls below) the fixed hedge price, however, this CFD will provide a poor hedge for the customer. On the other hand, the customer will profit under this CFD if the reverse is true. While a perfect *full* hedge for the customer is not possible, wind may provide an acceptable and attractive hedge if the prices faced by the generator and the customer are positively correlated, and production and consumptions patterns are reasonably well aligned. A primary focus of this paper is identifying the effectiveness of wind as a hedge given these imperfections.

Industry Experience with Using Wind as a Hedge. Most green power products sold in regulated and restructured markets in the United States do not offer truly fixed prices for generation service. Nonetheless, there is some experience in the U.S. in supplying the hedge value of wind to retail customers, especially hedges based on bundled renewable electricity service. In regulated markets, offering a fixed-price wind hedge is straightforward, and has been implemented successfully, as demonstrated by the experiences of Austin Energy, Eugene Water and Electric Board, and Xcel Energy. The competitive market experiences of Green Mountain Energy and Community Energy demonstrate offerings that have some of the characteristics of a wind hedge – fixed price and/or long-term. However, unlike monopoly markets, in restructured markets there is as yet no experience with successful delivery of a long-term wind-based hedge that benefits both wind generators and end-users. In Appendix A we summarize examples of

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[1] The CFD can take the form of a commodity hedge, where the strike price is set based on commodity market expectations and "green" attributes are sold elsewhere, or a green hedge, in which the strike price is set at a premium payment that assures the generator its full revenue needs. For further discussion and graphical examples, see Section 4.3 of the full report.

this industry experience from both regulated and restructured markets, demonstrating how the hedge-value of wind power can be delivered to retail customers, as well as the challenges of offering such products. We also discuss an example of C&I customers seeking renewable energy hedge products.

Challenges Facing Wind Hedge Products

We identify and describe in Section 5 six general challenges to developing and selling wind hedge products: lack of retail rate volatility, wind intermittence, locational basis differences, market resistance to long-term hedges, market resistance to customer switching, and credit risk. The first three of these challenges make wind power an imperfect retail hedge (the latter two of these are evaluated further in Section 6). For financial CFD wind hedge products, the risk manifests itself in the selection of an underlying price index that is either imperfect for the customer, or imperfect for the generator. For bundled renewable electricity service, the risk will generally be absorbed by the ESCO, which may be required to purchase spot electricity during periods of low wind generation and high customer load. The latter three challenges are more general difficulties in selling a wind hedge product.

- **Lack of retail rate volatility.** As noted earlier, retail electricity rates offered by New York's electric utilities may not match wholesale locational spot prices. As a result, customers may not face substantial enough price volatility to motivate them to hedge, or alternatively, the retail price volatility facing customer may be sufficiently different from wholesale volatility as to undermine the ability of an end-use customer to implement financial CFD hedges.
- **Wind intermittence.** Wind generation will not be perfectly coincident with any individual end-user's demand, making it an imperfect hedge. This mismatch between load and generation profiles can be manifested over the short, medium, and long term. In any given hour, either the seller or buyer of the hedge may face both price and quantity risk. Price risk reflects the unknown level and volatility of wholesale electricity prices encountered when covering any shortfall or unloading any excess wind generation. Quantity risk reflects the fact that electricity consumption will often be higher when prices rise (e.g., due to cooling loads); if wind generation is low during these periods, either the customer or the supplier will be particularly exposed to price volatility. In addition, because wind generation itself cannot be accurately predicted well in advance of delivery, the degree of non-coincidence is not perfectly predictable, making it unlikely that the wind hedge can be improved through conventional means in any given hour. Over a longer time frame, wind generation in New York might fluctuate by 10% or more from one year to the next simply due to variations in the annual wind resource. This adds the additional complication that the correct volume of a wind hedge can only be approximated.
- **Locational basis differential between wind generators and customers.** Due to transmission constraints and locational pricing, the wind generator and the customer may face different spot market prices. The differences in market prices faced by the generator and the customer may fluctuate over time, in a manner that is not perfectly correlated in direction or magnitude, introducing transmission basis risk. This may be a major issue in New York, where much of the wind development activity is in upstate zones that typically experience low wholesale prices relative to the more populated New York City area where many target

customers may be located. To mitigate this locational basis risk, the wind generator or the customer could purchase transmission congestion contracts. Such contracts are not available for terms matching a long-term wind hedge, however, and due to the intermittence of wind generation, purchasing transmission congestion contracts cannot perfectly hedge transmission congestion costs.

- **Market resistance to entering into long-term hedges.** To date, retail customers have expressed limited interest in long-term hedges (e.g., 10-20 years). Market research suggests that many customers dislike being locked into a contract more than they value the price guarantee that the contract provides. This resistance may be *the* critical barrier to offering a long-term wind-hedge product. The fact that few C&I customers have revealed an interest in hedging over the long-term could partially relate to the considerable uncertainty surrounding newly competitive retail markets. Moreover, some governmental customers are simply not allowed to enter into long-term electricity contracts, while many C&I customers may also have corporate policies that largely stymie such long-term contracting. Wind-based hedge products, however, may be able to combat customer concerns because they may be backed by a highly visible and tangible physical asset (i.e., the wind farm), engendering a sense of stability, permanence, and comfort among potential customers. In addition, financial wind hedge products do not require customers to switch electricity providers, allowing them the option of selecting a low-cost ESCO in conjunction with a separate wind hedge.

- **Market resistance to customer switching.** A wind-hedge based on bundled electricity service requires the customer to switch to an ESCO, unless the hedge product is offered by the incumbent utility. Many states do not yet offer retail customer choice, while those that do (including New York) often find that the act of switching suppliers is a barrier in and of itself. A financial wind hedge product, on the other hand, can avoid this barrier by allowing customers to maintain their current electric service provider.

- **Credit risk.** Credit risk is pervasive throughout the electric industry today. From a buyer's perspective, the credit risk (real and perceived) of the hedge seller is critical, particularly in long-term hedge deals in competitive markets. Exchange-traded futures and options (i.e., "traditional" hedging instruments) pose very little credit risk to the buyer. A wind hedge will take the form of an over-the-counter bilateral transaction, on the other hand, and may be offered by an ESCO or the wind generator directly. The specific credit risk to which a customer is exposed depends on whether the product is financial or physical. The sanctity of long-term wind-hedge products based on bundled electricity service will depend on the continued viability of the ESCO, while long-term financial CFD hedges will generally be more dependent on the continued viability of the generator. Because the generator owns the physical asset behind the product (i.e., the wind plant) and the retailer does not, financial wind hedge products may face lower perceived credit risk than bundled electricity products.

Analysis of a Retail Wind Hedge in New York

The combination of wind intermittence and locational basis differences between wind generators and end-use customers (discussed above) ensures that wind does not offer a natural "perfect" hedge for C&I customers. One could attempt to estimate the cost of "perfecting," or at least "improving," the hedge that wind power can provide in order to make it comparable to conventional wholesale hedge benchmarks. While such an assessment may be feasible,[2] it is beyond the scope of this report. There may also be sharply diminishing returns to perfecting a wind hedge: much of the cost of hedging is likely to be associated with improving the hedge from "pretty good" to a truly fixed price per kWh that will apply under all load conditions.

In Section 6 we prefer to look at the problem through a different lens: a wind-based hedge at retail may not need to be *perfect* in order to be *effective* for customers. Accordingly, here we focus primarily on evaluating the overall effectiveness of wind at hedging volatility and rising prices in the New York market, using scenario analysis. Though our analysis assumes a financial CFD wind-hedge structure, the basic findings are also relevant to bundled electricity service options. We do not address several additional questions necessary to fully characterize a wind hedge, however, including the cost of the wind hedge, the value of the hedge to retail customers, and the relative cost-effectiveness of a wind hedge compared to alternative hedging options.

This section begins by assessing the sensitivity of retail prices in upstate New York to the determinants of price risk in that region. We then use scenario analysis to assess the effectiveness of a wind power hedge to a large, high load factor customer located in the same LBMP zone as the generator. We then consider in sequence the effect of inter-annual variation in wind production, the effectiveness of hedging different (less idealized) load shapes, and the effectiveness of a wind hedge for customers located across congested transmission interfaces from the wind generator.

Sensitivity of Upstate New York Market Prices to Electric Price Risk Determinants. We begin Section 6 by considering the electricity price risks faced by large New York end-use customers within the same locational pricing region as a wind plant. Since the majority of current wind development in New York is in the upstate area, largely in a locational pricing region referred to for our purposes as *NY-West*, we first concentrate on the determinants of electricity price risk in NY-West. Later we discuss the use of wind as a hedge for customers in the higher-price New York City region, which requires consideration of transmission bottlenecks and locational basis differences in market prices.

Our analysis finds that wholesale electricity prices in the NY-West region are sensitive to fuel price risk, as well as changes in the overall supply-demand balance, lack of demand response, and the bidding behavior of generation owners. For these risks, which may act to increase or decrease market prices, hedging brings greater certainty. In addition, due to substantial reliance on coal and other fossil-fuel generation, market prices in this territory are exposed to the one-way risk of increased environmental compliance costs.

Hedging an Annual Electricity Bill – Same Zone Analysis. We first assume that the wind generator and the customer are both located in NY-West. We consider a typical three-shift industrial customer (85% load factor) purchasing electricity under an ESCO wholesale spot market pass-through pricing structure, who separately contracts with a wind generator for a

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[2] Some of the mechanisms that could be used to perfect a wind hedge include: purchasing wind risk insurance products to shift the financial consequences of inter- or intra-annual variance in production to third parties; combining wind hedge purchases with conventional hedges or energy call options during seasons in which wind production is low; installing on-site peaking generation to protect the customer against high energy price spikes; or entering swaps with wholesale intermediaries to effectively convert variable and intermittent production streams into fixed blocks of energy.

financial CFD hedge indexed to the local energy LBMP. We use one year of actual output from an operating wind farm located in NY-West, and hold that production constant from year to year in both total energy output and hourly profile.

We test the effectiveness of using wind as a hedge in this environment by looking backward and observing how hedging approaches would have worked under historical LBMP prices. Our historical LBMP data set, covering May 2000 through December 2002, provides a significant degree of insight, as the movement in NY-West market prices during that period covers a representative range of experience.

Using the data and assumptions described above, superimposed on historical LBMP prices in NY-West, we compared the variability of the customer's electric bill under an unhedged ESCO wholesale spot market pass-through pricing structure with four simple hedging approaches:

(a) *100% wind hedge*: A wind CFD whose expected annual volume (in MWh) matches the customer's anticipated annual load. Note that this results in wind production substantially exceeding the customer's winter loads, while constituting a partial hedge position in summer months.

(b) *50% wind hedge*: A wind CFD whose expected annual volume equals 50% of the customer's anticipated annual load. In this case, the wind production volume during winter months approximates the customer's winter load while leaving the customer less hedged in the summer.

(c) *Wind hedge plus conventional block forwards:* A wind CFD sized to match the customer's *winter* usage, combined with a conventional *summer* seasonal forward block purchase. The total combined quantity of the hedge is sized to match 100% of the customer's total expected annual load, with the wind hedge comprising 77.3% of the volume, and the conventional hedge the remainder.

(d) *Conventional block forwards:* A conventional annual forward block purchase, sized at a constant hourly scale to match the customer's annual average load (e.g. sized to match 100% of the customer's total expected annual load). This represents the benchmark, a conventional financial approach that may be used by a number of customers today.

In each case, the strike price was set at the average historical LBMP, so as to reveal the hedge effect without introducing any absolute, directional bias.

Our backward-looking analysis reveals that if sized effectively or combined with other strategies, wind hedges may be able to produce results, on an expected value basis, approaching those that could be provided by a conventional hedge purchase of similar duration.[3] Figure ES-1 compares the annual bill under spot, and spot + 100% wind scenarios, as a percentage of each scenario's average annual bill, for four staggered 12-

TableES-1: Relative Stability of Annual Bill

	All Spot	Spot + 100% Wind
12 months ending 6/01	114%	96%
12 months ending 12/01	104%	102%
12 months ending 6/02	88%	102%
12 months ending 12/02	94%	100%

[3] Note that even for this very high load-factor end-use customer, a conventional block forward approach is a very good, but still not perfect, hedge.

month periods within our historical period, while Table ES-2 compares the standard deviations of monthly bills and average price over the historical period. While there is significant month-to-month variation, all three wind hedge alternatives appear quite effective at stabilizing monthly and annual electricity prices for a baseload C&I customer in NY-West. Hedge strategies using

TableES-2: Comparison of Standard Deviations between Spot and Hedged Electric Supply for High Load Factor Customer

	All Spot	Spot + 100% Wind	Spot + 50% Wind	Spot + Wind & Summer Forwards	Spot + Conventional Forwards
Standard Deviation of Monthly Average Bill (as % of avg.)	19.9%	7.9%	10.2%	3.9%	2.9%
Standard Deviation of Monthly Average Price (as % of avg)	19.2%	9.0%	9.8%	3.3%	1.8%

wind would have dramatically reduced the degree of variation of bills over time and in aggregate, despite volatile spot market prices and intermittent wind production. Since a primary motivation for some C&I customers to hedge may be fixed energy budgets, this annual stabilization appears to be an important result.

The Effect of Annual Wind Production Variability on Hedge Value. In the previous section we concluded that a wind CFD between a large end-user with a nearly flat load profile and a wind generator in the same zone, at least within NY-West, can significantly dampen the volatility in a customer's annual electricity bill. The analysis leading to this conclusion ignored one important variable, however: fluctuations in production – both total and among months – from year to year. Quantifying the specific impact of such annual variations in wind generation profiles is beyond the scope of this paper. Nonetheless, we believe that the historic period assessed in the previous section contains periods with intra-annual variation well surpassing the expected inter-annual standard deviation of 8-12%. Furthermore, derivative products are being developed for the wind power industry to insure against inter-annual wind resource risk.

Hedging Different Retail Load Shapes. We have so far considered only the usefulness of a wind hedge for a very high load-factor customer. While it would be straightforward to repeat the analysis with a variety of load shapes, such analysis is not necessary to draw meaningful qualitative conclusions.

As a proxy for the value of wind hedges in both a portfolio context and for a customer with *average* load shape, however, we re-ran the analysis described earlier for a customer with a load profile mirroring the aggregate NYISO profile. As shown in Table ES-3, based on our backward-looking process using actual market prices, the various wind hedge approaches identified earlier reduce the volatility experienced by such a customer substantially, but less effectively (roughly two-thirds as effectively) than in the case of the high-load factor customer considered earlier. The weakened effectiveness of the wind hedge product in this case is due to the fact that the NYISO aggregate load is more heavily weighed towards summer peak (which are generally low wind months) than the hypothetical baseload customer used earlier.

The determining factors of the degree to which a specific C&I customer will derive maximum effectiveness from a wind hedge will be usage during periods of high volatility, and coincidence of load with wind production. For example, the winter-oriented wind production in NY-West suggests that facilities with particularly winter-oriented end-uses without corresponding summer load may be particularly well suited for a wind hedge in NY-West. Examples include electric heat customers, ski areas, educational facilities that do not have much summer load, or perhaps even streetlight loads. The converse is also true: customers with summer-peak intensive usage, particularly high air-conditioning loads, may not find a wind-only hedge to be as effective, although if combined with other hedge options, a wind hedge may still have value.

TableES-3: Comparison of Standard Deviations between Spot and Hedged Electric Supply

For Customer with Average NYISO Load Shape

	All Spot	**Spot + 100% Wind**	**Spot + 50% Wind**	**Spot + Wind & Summer Forwards**
Standard Deviation of Monthly Average Bill (as % of avg.)	24.7%	14.3%	17.2%	10.7%
Standard Deviation of Monthly Average Price (as % of avg)	18.6%	9.8%	10.0%	3.9%

Hedging an Annual Electricity Bill with the Generator and Customer Located in Different Zones. The highest and most volatile electricity costs in New York State are in New York City and Long Island, areas subject to significant transmission constraints and with minimal opportunities for on-shore wind power development. One would expect New York City and its suburbs to also host the highest concentration of customers potentially interested in buying wind as "green power". The final step of our analysis considered the value of a wind hedge when the wind generator is in a different zone than the end-use customer. In particular, we consider the effectiveness of a hedge from a wind plant in NY-West from the perspective of a customer in New York City (NYC).

In New York's wholesale market structure, when the location of the generator and the customer are in different zones, between which there is frequent transmission congestion, a basis difference is introduced between the generator and customer, as described earlier. Transmission congestion risk is introduced. While there are tools available to hedge this transmission risk – called transmission congestion contracts (TCCs) – this risk cannot be hedged perfectly due to a combination of wind intermittence, rigid dimensions (size and shape) of TCCs, and the different shapes of wind generation and customer load. Nonetheless, a wind hedge may still be effective enough to provide value to a customer.

We tested this hypothesis by performing the same analysis described earlier (but only for a 100% wind hedge), except that the customer's commodity electricity price is tied to the NYC LBMP, while the wind CFD remains indexed to the NY-West LBMP. This approach provides a perfect hedge for the generator, but perhaps a weaker hedge for the customer than if the customer were located in NY-West. The results of this analysis, looking at the same May 2000 through

December 2002 historical period of actual LBMP prices in NYC and NY-West used earlier, suggest that the 100% NY-West Wind Hedge would provide reasonable hedge value to a NYC customer, in addition to being a perfect hedge for the generator. As shown in Table ES-4, the 100% NY-West Wind Hedge leads to a 40% reduction in the volatility of monthly average electricity prices and bills, relative to an unhedged commodity electricity purchase. The explanation for this phenomenon is that the two LBMPs are directionally correlated in most hours, if not tightly correlated in magnitude, so that some hedging effect is seen.

TableES-4: Comparison of Standard Deviations between Spot and Hedged Electric Supply for a Customer in New York City Hedging with a NY-West Wind Project

	All Spot	NYC Spot + 100% NY-West Wind
Standard Deviation of Monthly Average Bill (as % of avg.)	20.9%	12.7%
Standard Deviation of Monthly Average Price (as % of avg)	20.2%	12.3%

Alternatively, the wind CFD could be indexed to the NYC LBMP (instead of NY-West), exposing the wind generator to an imperfect hedge but presumably improving the hedge value for the customer. In this case, the wind generator could either accept the less-than-perfect hedge, or try to hedge the transmission congestion risk by scheduling power into the NYC zone through a bilateral transaction, and then purchasing TCCs. Our preliminary analysis shows that, in the first case (where the generator accepts the imperfect hedge), the customer does garner additional hedge value, but that depending on the strike price chosen and the movement of prices, there could be a net gain or loss to the generator, the customer, or both. A more comprehensive analysis of this situation, as well as the degree to which the transmission basis difference could be hedged with adequate cost-effectiveness to justify the second approach, is beyond the scope of this paper, but is ripe for further study.

Conclusions and Next Steps

Based on this study, we conclude that wind-generated electricity can provide important hedging benefits to New York's wholesale electricity markets, but that providing this benefit to individual C&I customers is challenging. The structure of retail rates can insulate customers from the full impact of wholesale price volatility. Retail customers who do experience price volatility may be in different locations from the wind generator or have usage profiles that are not well matched to wind production profiles. Finally, customers in general may be averse to switching retail suppliers or otherwise entering into long-term hedges for many reasons, including concerns over counter-party credit quality. These barriers to using wind as a retail wind hedge can be significant, and suggest that retail wind hedge tools may be most attractive to a limited segment of the C&I market.

Despite these barriers, our analysis suggests that wind can provide a good, if not perfect, hedge for many C&I customers. Alternative means of hedging are also imperfect, and face many of the same barriers facing wind hedges, yet they clearly have value to some customers. Furthermore, the availability of conventional hedging instruments over longer terms appears to be limited. Thus, while opportunities for wind power hedging against retail electricity price volatility may not be pervasive, there are certainly applications and certain customer types that merit further attention. Further investigation of these opportunities is warranted.

Yet it is difficult to conclude that wind's hedge value alone – i.e., apart from its environmental benefits – is enough to make it a superior resource choice. In other words, though difficult to quantify, the hedge value of wind power is unlikely to sufficiently cover the full direct cost premium for wind power in New York with today's technology. This observation, however, does not mean that wind does not provide significant value as a hedging tool in certain circumstances – value that can factor into the sales pitch of wind sellers if the wind product is structured as a hedge. Furthermore, wind power has other "green" attributes that are valued by customers, as well as by policymakers and retail electricity suppliers. Since (in principle) the products and services created by wind generators can be unbundled and sold independently, wind's hedge value perhaps need not support wind's full cost premium above commodity market value; wind's green attributes can also provide premium support although a lower premium may be required if the hedge value can be captured independently.

Given the potential for wind hedge product development, there are several avenues that merit further consideration by NYSERDA.

- **Support development of a base of experience with retail wind power hedges.** Some consideration should be given to: (1) supporting a demonstration project, in which expertise is provided to facilitate the development of a retail wind hedge transaction, or (2) undertaking a more comprehensive project by subsidizing a retail ESCO or a wind generator that develops and tries to sell such a product.
- **Remove remaining unhedged risks from wind hedge transactions.** Alternatively, by helping to perfect wind hedges, current barriers to parties entering into wind hedge transactions could be removed. This could be accomplished by (1) funding or insuring hedge transactions against the transmission basis differences between LBMP zones (or perhaps even against the mismatch between generation and load, which includes basis but also includes load/generation mismatch), and/or (2) enticing one or more firms to offer wind insurance products in New York by sharing some of the risk.
- **Fund additional areas of study.** NYSERDA might also consider funding research to further flesh out the viability of using wind as a retail price hedge for C&I customers in New York. Specific areas of further study that we believe worthy of attention include: (1) conducting a survey of C&I customers' interest in hedging electricity price risk, particularly with a wind-based product, and (2) more thoroughly assessing the effectiveness of a wind hedge when the customer is in a different LBMP zone than the generator. Studies that deserve lower priority attention include: (1) testing the preliminary conclusions reached using historical data in this report with hypothetical future market price and production data, (2) testing the effectiveness of a wind hedge for other retail load shapes, and (3) more thoroughly assessing the effect of annual wind production variability on hedge value and effectiveness. Finally, an important area of study that is related to our topic, but that is outside the scope of our effort, is an assessment of the effectiveness of wind as a hedge against gas price escalation more generally.