UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMISSION

ISO New England Inc. and	**)**	**Docket No. ER14-_____-000**
New England Power Pool	**)**	

TESTIMONY OF PETER CRAMTON
ON BEHALF OF ISO NEW ENGLAND INC.

I. WITNESS IDENTIFICATION

Q: Please state your name, title, and business address.

A: My name is Peter Cramton. I am a Professor of Economics at the University of Maryland. My business address is Economics Department, University of Maryland, College Park, MD 20742.

Q: Please describe your work experience and educational background.

A: I am a Professor of Economics at the University of Maryland. Since 1983, I have conducted research on auction theory and practice. This research appears in the leading economics journals. The main focus is the design of auctions for many related items. Applications include spectrum auctions, electricity auctions, and treasury auctions. On the practical side, I am Chairman of Market Design Inc., an economics consultancy founded in 1995, focusing on the design of auction markets. I have advised numerous governments on market design and I have advised dozens of bidders in high-stake auction markets. Since 1997, I have advised ISO New England Inc. ("ISO") on electricity market design and was a lead designer of New England's Forward Capacity Market ("FCM"). I led the design of electricity and gas markets in Colombia, including the Firm Energy Market, the Forward Energy Market, and the Long-term Gas Market. Since 2001, I played a lead role in the design and implementation of electricity auctions in France and Belgium, gas auctions in Germany, and the world's first auction for greenhouse gas emissions held in the UK in 2002. I led the development of innovative auctions in new applications, such as auctions for airport slots, wind rights, diamonds, medical equipment, and Internet top-level domains. I received my B.S. in Engineering from Cornell University and my Ph.D. in Business from Stanford University.

II. PURPOSE AND OVERVIEW OF TESTIMONY

Q: What is the purpose of your testimony?

A: The purpose of my testimony is to comment on the ISO's proposed Pay For Performance ("PFP") reforms to its FCM.

Q: Can you summarize your main points?

A: Yes. I wish to emphasize four main points about the PFP design. First, PFP is an economically sensible design based on sound market principles, appropriately applied to capacity markets. Second, PFP fixes important shortcomings of the current FCM. Third, a high performance payment rate is appropriate and is economically well-justified. Fourth, PFP induces a FCM with desirable long-run properties. My testimony will explain each of these points in detail.

<u>III. PFP IS AN ECONOMICALLY SENSIBLE DESIGN BASED ON SOUND PRINCIPLES FOR CAPACITY MARKETS</u>

Q: What are the key principles of the PFP design?

A: The most basic principle of the PFP design is in its name: *pay for performance*. Resources earn the capacity payment based on performance during scarcity conditions. This is accomplished through the definition of the capacity product, which includes an obligation to supply during hours of reserve shortage. Resources are paid based on the service provided. If a resource meets its performance obligation, it receives its full capacity payment; if the resource underperforms, it receives a smaller payment; and if the resource over-performs, it receives a larger payment.

The supply obligation is load-following, so that consumers are fully-hedged, but not over-hedged. In any scarcity hour the total supply obligation equals total demand—load plus reserve requirements.

Q: Why is it economically sensible to put stronger performance incentives in the capacity market?

A: The motivation for the capacity market is to address a demand-side flaw, the absence of demand response. This causes the energy price to be set too low during periods of scarcity, creating missing money. One could restore the missing money with an “energy only” design by setting a high scarcity price during hours of reserve shortage. The scarcity price would be set in the ISO Tariff to induce the desired level of reliability. The PFP design in the FCM works in the same way as the “energy only” design, but with a forward contracting model that addresses several problems of the “energy only” design. Specifically, the forward contracting coordinates investment at the desired reliability level, reduces payment risk for both consumers and generators, and mitigates market power in the energy market during periods of scarcity.

PFP provides the same strong performance incentives as in the “energy only” market with an appropriately set scarcity price. This is accomplished by paying resources based on performance during reserve shortages.

Q: Are there other key principles of the PFP design?

A: Yes. A second principle is *resource neutrality*. A resource should receive the same compensation for the same performance, regardless of technology. This “equal pay for equal work” is grossly violated in the current design. Unreliable resources that fail to provide energy or reserves in shortage situations often receive the same compensation as reliable resources that do provide services during shortages.

A third principle is to *reward outputs, not inputs*. In most markets, consumers pay for the goods and services delivered. Payments are based on outputs of production, not inputs. The PFP design works in the same way. Consumers pay for what they value. PFP also simplifies the market, since there is just a single product and a single price, or one per zone in the event zonal constraints bind. All suppliers and technologies compete on the same basis. Suppliers that can more efficiently convert inputs to outputs are rewarded.

Q: Doesn't the PFP design cause suppliers to bear performance risk?

A: Yes. With PFP, suppliers do bear performance risk. This is both intended and appropriate. Performance risk must be borne by consumers or suppliers. Putting performance risk on suppliers is desirable, since suppliers make a variety of decisions that impact performance. It is this performance risk that motivates good supplier decisions. A supplier will not invest in performance improvements if the supplier does not bear the risk and receive the rewards for its performance. The performance incentives cause the supplier to see and feel the economic consequence of decisions that impact performance. Furthermore, having consumers bear the performance risk is wholly inappropriate; they can neither control that risk nor change suppliers' behavior to manage the risk. Likewise, it is equally inappropriate to socialize the risk among all resources. Incentives and consequences need to be placed directly upon the resources that can control them.

Q: But some events that impact performance are not within the supplier's control. Is it still desirable to base payments on outputs?

A: Yes. There are two main reasons why this is desirable. First, risks not subject to a supplier's control must be borne either by consumers or the supplier. Consumers have no control of these risks either, so there can be no incentive benefit in placing this risk on consumers.

Second, placing the risk on the supplier affects what clears in the capacity market in ways that are desirable from both an economic and a reliability standpoint. Specifically, a supplier that is less likely to perform, even if due to reasons beyond the supplier's control, will place a higher offer into the FCA to account for this risk. As a result, the less reliable supplier will be less likely to clear. This mechanism—placing risk on suppliers, rather than on consumers, for factors outside of either party's control—enables the capacity price mechanism to work in an economic manner to clear the resources that are most likely to deliver when they are needed.

This approach also simplifies the market, because it is unnecessary to assign blame for failures to perform. The market simply measures output during scarcity.

Q: Can you describe the mechanics of the PFP design at a high level?

A: PFP is a two-settlement design—a forward sale that is then settled based on deviations at delivery. There is nothing novel or complicated about this design. It is equivalent to the structure of the energy market and many other forward contracts. Each supplier takes on a forward obligation and then covers that obligation with its own supply or purchases supply from others. The principal difference between PFP and a forward energy contract is that with PFP it is necessary to set the settlement price (the performance payment rate) in the ISO Tariff, since in a shortage situation there are no competitive offers with which to determine a market price.

The PFP design shares the same key benefit of other two-settlement systems: efficient performance. The capacity supplier faces strong marginal incentives to perform during shortages and any deviations from forward obligations are automatically settled at delivery. Poor performance is not "penalized." Rather, deviations both positive and negative are settled at the performance payment rate. A negative deviation is simply a purchase of supply through the pool from another resource at the time of delivery.

Q: Are there exemptions in the two-settlement design for non-performance?

A: There are no exemptions. This is a critical feature in simplifying and improving the market. A policy of no exemptions provides strong and uniform performance incentives. It is a hallmark of two-settlement designs. Deviations from forward obligations are settled at delivery. No exemptions.

This is just like in the day-ahead energy market. When a supplier fails to deliver on its day-ahead sale, the deviation is made up with a real-time purchase. There is no debate about why the supplier was short and whether the deviation was justified. This lack of exemptions is what makes the two-settlement design so effective. Obligations and remedies are clear.

As another example, consider the forward grain market. Suppose the farmer sells a quantity of grain forward at a fixed price. He bears all the risk of factors—either positive or negative—that impact his performance. If there is a drought and his harvest is poor, he covers any shortfall with a spot purchase at the higher market price caused by the drought. If the farmer's yield is especially high, any surplus beyond the forward obligation is sold at the spot price. If the farmer's grain is destroyed in transit, the forward obligation is met with a spot purchase. All deviations, whatever the cause, are settled at the spot price.

A supplier of course likes exemptions consistent with the chief weaknesses of its fleet. Slow-start resources want to be exempt unless given sufficient advance notice of a shortage; resources with long maintenance outages want an exemption for planned maintenance; resources in locations vulnerable to transmission problems want transmission exemptions; resources with fuel delivery challenges want a no-fuel exemption. The list is endless.

However, in each of these cases, despite the chorus of “it’s not my fault,” some of the resource’s reliability weakness is the supplier’s fault. The supplier can invest in more responsive resources; the supplier can shift its obligation to another during scheduled maintenance; the supply can locate where transmission is more robust; and the supplier can invest in dual-fuel capability to protect against gas delivery problems.

Introducing exemptions distorts incentives, favoring some suppliers at the expense of others. For example, a transmission exemption encourages resources to locate in areas with transmission problems. These resources are paid for more reliability than they deliver.

A policy of no exemptions creates a level playing field. Responsibilities are clear and settlement is straightforward. Suppliers do bear greater performance risk, but it is precisely this risk that motivates performance-improving investments.

Q: But in many cases the relevant decisions that impact performance were made long ago. Why should these resources face high marginal incentives to perform?

A: It is important to remember that the FCM is a long-run market. The market must provide incentives that work well in the long run, both before and after investments are made. Indeed, a primary goal of the capacity market is to motivate efficient investment in the right resources. High marginal incentives reward long-run investments that improve performance and reliability. Without these strong incentives, costly investments to improve performance would not be made. Moreover, these strong incentives must be maintained throughout the life of the project for this is the assumption on which the investment is initially made.

Even after long-run investments have been made, strong performance incentives are needed to foster medium and short-term investments in reliability. Investors, seeing the price incentive, can respond creatively to offer consumers reliable supply at least cost. For example, by lining up replacement supply during a long outage or investing in more reliable fuel delivery. Suppliers are not told what to do; they are simply rewarded based on the output delivered. This is the chief advantage of using prices to motivate behavior and is the hallmark of a market-based system.

Q: But don't these strong performance incentives make supplier revenues highly volatile?

A: No. An important feature of the PFP design is to reduce the volatility of supplier revenues and consumer expenditures from year to year relative to an "energy only" market design. The risk reduction stems from the way the capacity payment substitutes for the energy rents that otherwise would be earned during scarcity hours. Specifically, the capacity payment reflects the *expected* energy rents during scarcity (a constant), rather than the *actual* energy rents during scarcity, which vary greatly from year to year as a result of many random events. A supplier that meets its share of the system performance obligation on average over the year has a net performance payment of zero, and receives its full capacity payment. Suppliers on average do meet their obligations, aside from the small quantity of MWh unserved during reserve shortages. The supplier's capacity and fuel contracts serve to hedge the risk stemming from the capacity supply obligation. Consumers meanwhile pay a fixed amount for energy during scarcity hours. Risk is reduced on both sides of the market.

Variation in supplier payment is limited to deviations in performance. The only way to further reduce supplier risk would be to weaken performance incentives. But this would compromise the good investment incentives that PFP creates. Instead, in the PFP design, suppliers reduce risk through investments that improve the reliability of their resources. Thus, PFP reduces supplier risk to the extent possible without damaging the incentives to invest in reliability.

Q: Won't this make capacity expensive for consumers?

A: No. In fact, over the long-run the PFP design will reduce the total cost of reliable energy supply. This is because the PFP design identifies the most cost-effective resources to meet the Installed Capacity Requirement, as I explain below.

Q: Can a supplier also mitigate risk through its bidding in the Forward Capacity Auction ("FCA")?

A: Yes. To minimize risk, a supplier adjusts its bids in the FCA based on the cost of providing reliable performance. For example, consider a 100 MW resource that expects to have a net performance payment of zero with a 60 MW capacity obligation, in other words no performance deviations at the 60 MW level. It would be risky for the resource to take on a capacity obligation greater than 60 MW. Thus, the resource can offer its first 60 MW of capacity into the FCA at a low price and then offer the remaining 40 MW at a higher price, reflecting the greater risk of these additional MWs. Such a bidding strategy is economically sensible. Taking on a capacity obligation consistent with the unit's expected performance reduces risk—the resource provides an excellent hedge for the obligation. But selling additional capacity beyond a unit's expected performance increases risk and needs to be priced higher to account for the additional risk. The supplier's increasing offer schedule reflects the increasing risk of higher levels of capacity obligation. A simple example of this would be the highest block for a combined cycle gas plant. To get the highest megawatts out of the unit will be both much more costly and subject to higher risk. Thus, this last block will be offered at a higher price and will only clear if no other, less expensive resource can take on the obligation.

Q: Doesn't PFP sometimes penalize suppliers for following ISO dispatch instructions?

A: No. Resources are not penalized for following instructions; rather, payments are reduced for failing to meet an obligation to deliver energy or reserves during a shortage. In fact, the ISO would like the resource to run to help meet energy and reserve needs, but the ISO dispatch instructions reflect a variety of constraints that prevent the unit from running. This could be because of unit limits (start time, ramping rate, etc.) or transmission system limits (inadequate capability). In any event the dispatch instructions reflect what the unit is able to do, not just what the ISO would like the unit to do. This is just another version of the argument that resources should receive exemptions from circumstances allegedly outside of their control, in this case the operational constraints included in the ISO's commitment and dispatch software, and that is false.

As an example, a high-cost resource with a long lead time may not be committed and therefore the resource is not able to supply energy or reserves during a shortage. Its failure to perform means that the resource did not contribute to reliability. The resource therefore should be paid less, even though it followed dispatch instructions. It was not asked to run, because it could not get online in time to reduce the shortage.

The folly of paying non-performing resources is easy to see with an extreme example. Consider a resource with a lead time and marginal cost that are so high that the resource is never committed. Were resources paid for following dispatch instructions then this resource would receive full payment: it never is asked to run and never does so. But this resource clearly makes zero contribution to reliability. It should be paid zero. Following dispatch instructions is not a measure of a resource's contribution to reliability. Supplying energy or reserves during scarcity hours is.

<u>IV. PFP FIXES IMPORTANT SHORTCOMINGS OF THE CURRENT FCM</u>

Q: Please describe some of the problems of the current FCM and explain how the PFP design addresses these problems.

A: There are several problems with the current FCM. The problems stem from performance incentives being too weak. I will consider each of the problems in turn.

One of the biggest problems is the use of "availability" to measure performance. Currently, there is little consequence for non-delivery during reserve shortages. The reason is the large number of exemptions that crept into the FCM settlement. Resources are credited for being "available" even when they provide no energy or reserves during scarcity conditions.

Availability-based obligations have proven to be a poor design. The availability approach results in the same compensation for different levels of service. High cost, long lead-time resources receive the same payment as low cost, quick start units, even if the latter contribute much more to reliability by providing energy and reserves during scarcity hours. This undermines incentives to invest in short lead times and other resource attributes that improve performance during shortages.

A further problem with availability-based obligations is that a resource can claim to be available even when it is unlikely it will perform if called. The availability claim is successful when the resource is not called to provide energy. Thus, it is high-cost slow-start resources that are less apt to have their availability tested. The availability metric perversely rewards resources for being less desirable (*e.g.* expensive or slow to start) since they are less apt to have their performance tested.

As an example, consider a resource that does not have dual fuel capability and has not made advance arrangements for fuel and, as a result, faces considerable uncertainty as to whether it could acquire fuel during the operating day. The availability approach gives this resource the incentive to report it is available up until the point when the resource is needed and is called to deliver energy at which point the resource is unable to start for lack of fuel. From a reliability perspective, this is the worst possible outcome. The system operator is relying on the resource to be available if needed, and then the ISO discovers this is not the case. But now it is too late to avoid a scarcity condition.

Q: Are there other problems with the current FCM?

A: Yes. Another problem in the current market is the inadequate incentive suppliers have to invest in reliability-enhancing capabilities that are useful only a few hours per year. Dual fuel supply is a lead example. New England's heavy reliance on gas and its position at the end of the gas network makes New England especially vulnerable to inadequate gas supply. Backup fuel supply could resolve this systemic reliability risk. However, the current FCM provides little incentives for such investment.

The PFP design greatly improves incentives for investment in resource capabilities that are needed only a few hours per year when the system's reliability is at a heightened risk. By rewarding performance during scarcity hours, PFP targets exactly those investments that improve performance during scarcity events.

Q: In the current market does a non-performing resource receive capacity revenues?

A: Yes. This is the "money for nothing" problem. The current FCM pays capacity resources that do not perform. As a result, it is profitable for a resource that only operates for its annual capability audit to take on a Capacity Supply Obligation ("CSO"). The resource may contribute little, or even zero, to reliability and yet enjoys capacity revenues.

Q: What is the implication of overpayment for poor performers in the current market?

A: As a result of overpaying poor performers, the current FCM suffers from adverse selection. Rather than clearing those resources that achieve the reliability objective at least cost, the market favors less reliable resources. Units with low going-forward costs and poor performance clear before more cost-effective resources that have higher going-forward costs and better performance. The reason is that the performance rewards in the current FCM are inadequate. Weak performance incentives bias the market in favor of less reliable resources. Over time, this bias erodes reliability in New England.

An implication of this adverse selection is the “effective capacity” problem. Effective capacity is the quantity of energy and reserves that the resource delivers during scarcity conditions. Effective capacity may be worse than one would expect based on the Equivalent Forced Outage Rate (EFORd) currently used to set the Installed Capacity Requirement in the FCM. The reason is that weak performance incentives adversely select resources that perform poorly during scarcity hours. Available resources are often not accessible in time to deliver during scarcity conditions. EFORd ignores this, since it only downgrades a resource’s performance when it fails to operate when called with adequate lead-time. This introduces a systemic bias in the measurement of effective capacity that reduces system reliability.

The PFP design addresses this problem by clearing resources that expect to perform, rather than systematically selecting underperformers.

Q: Do you see any other flaws in the current market?

A: Yes. Another issue with the current market is the "free option" problem. The current FCM has penalty caps that prevent a net loss on FCM obligations. This means poor performers are playing a game of heads-I-win, tails-I-don't lose. As a result, poor performing suppliers are encouraged to participate in the market when they should exit. This is similar to but distinct from the "money for nothing" problem. The free option problem relates to the downside truncation of any losses when faced with uncertain performance.

Under PFP, resources can have a loss in the capacity market if they perform poorly in a year with a large number of scarcity hours. There is still a limit to losses, but not a complete elimination of the possibility of a loss. The stop-loss limit under PFP is specifically designed to rarely bind and therefore to only rarely harm incentives.

Q: As an expert in market design, is there a root cause that underlies the flaws you have identified in the current FCM?

A: Yes. The basic problem with the current capacity market is the absence of a coherent capacity product definition. Good product definition is essential to all markets. The current FCM product lacks clarity as a result of exemptions and a questionable availability metric. The product is needlessly complex. Furthermore, the too-weak performance incentives create the wrong investment incentives. Unreliable resources are encouraged. The product provides poor incentives for investments that would contribute to system reliability by improving performance during scarcity.

In contrast, the PFP design has a simple and coherent product definition: physical capacity together with a financial obligation to cover a share of demand during hours of reserve shortage. The physical component guarantees that adequate physical resources will be available. The financial component provides the performance incentives. Since the financial component is a standard two-settlement forward contract, it is easy to create and trade a matching financial security that hedges performance risk. Suppliers anticipating underperformance, say as the result of an extended outage, can purchase the hedge from suppliers anticipating over-performance. Thus, the coherent product motivates efficient performance and enables suppliers to better manage performance risk.

V. A HIGH PERFORMANCE PAYMENT RATE IS NEEDED FOR EFFECTIVE PERFORMANCE INCENTIVES

Q: On what basis is the performance payment rate determined?

A: The performance payment rate ("PPR") follows directly from two basic economic principles. The first is that new capacity must be willing to enter the market when new entry is needed to meet the Installed Capacity Requirement. The second is that a resource that provides zero performance should expect to receive zero revenue. Thus, a resource's expected payment increases linearly from zero with zero performance to 100% of the net cost of new entry (net "CONE") for an efficient new resource that performs as expected.

Ignoring risk for the moment, new capacity that performs as expected is willing to take on the supply obligation if the capacity price, which in equilibrium must be net CONE, is equal to the expected scarcity rents that are earned in the scarcity hours:

Capacity price = Net CONE = PPR × Expected scarcity hours × Expected scarcity performance.

Thus, PPR = Net CONE / (Expected scarcity hours × Expected scarcity performance). The performance payment rate simply amortizes the net cost of new entry over the expected production of energy and reserves in scarcity hours.

The ISO has estimated the three parameters that determine the performance payment rate as follows:

PPR = Net CONE / (Expected scarcity hours × Expected scarcity performance)

PPR = ($106,394 / MW-year) / (21.2 hours/year × 0.92) = $5,455 / MWh.

The PPR reflects the reliability criterion through the expected number of scarcity hours in the year. The ISO's planning model shows that when the system satisfies the reliability criterion the expected number of scarcity hours is 21.2. A lower level of reliability would lead to more scarcity hours and a reduced PPR.

The PPR also depends on the expected performance rate, which currently is 0.92 for the type of new generation that the ISO has estimated to be the most cost-effective entrant (a combined cycle unit). Improvements in a new entrant's expected performance would result in a lower PPR, and lower FCM clearing prices; however, given that performance cannot exceed 1.0, there is little scope for improvements in expected performance to have much impact on PPR. Thus, it is unlikely the PPR would need to be modified in future years for this reason.

Finally, the PPR directly depends on net CONE. Net CONE can change in two ways. First, there might be a change in costs. Second, rents in the energy and reserve markets may change. Either of these factors may change over the long term, as technology changes and the energy market evolves.

The PPR should be updated every few years so that it stays at the level consistent with the two basic principles of: (1) supporting entry when needed; and (2) zero pay for zero performance.

Q: What are the advantages of setting the PPR at this level?

A: There are several. The first is good incentives. PPR calculated in this way closely aligns the reward for performance during times of system stress with the region's desired level of reliability. This reward motivates suppliers to make reliability enhancing investments such as dual-fuel capability. Suppliers also properly consider the reliability tradeoffs when investing in new resources.

A second advantage is that it is cost-effective. The FCA clears the lowest-cost set of resources necessary to satisfy the reliability standard. Resources that are not cost-effective exit the auction because the capacity payment provides insufficient revenues to cover costs. I explain this further below.

A third advantage is transparency. Fixing the PPR in the Tariff helps guide long-term investment decisions and facilitates contracting to hedge performance risk, for example during extended outages.

<u>VI. THE PFP DESIGN HAS DESIRABLE LONG-RUN PROPERTIES</u>

Q: What are the long-run properties of the PFP design?

A: Perhaps the most important property of the PFP design is that it clears the most cost-effective set of resources to meet the ISO’s reliability planning requirements. Cost-effectiveness is measured as cost / performance. Resources clear in the FCA based on the capacity cost per MWh delivered in scarcity conditions. The most cost-effective resources clear first.

The reason that under PFP the market clears the most cost-effective resources is simple. Since resources are paid based on performance, better performers earn higher net FCM revenue and poorer performers earn less. All resources that clear have positive expected net FCM revenue, because they are sufficiently cost effective. Resources that do not clear in the FCM are not profitable either because they have high costs, poor expected performance, or both.

In contrast, the current market clears on capacity cost alone, regardless of what performance consumers get for the money. This adversely selects less reliable resources. Consumers are somewhat compensated with a lower capacity price, but overall consumers today end up paying more relative to what they get for their money. This is because many poor performing resources are selected even though they are not as cost effective as some high performing resources that do not clear. Without strong performance incentives, high performing resources are inadequately rewarded for their performance and choose not to participate.

Consumers "get what they pay for" with PFP, since resources are compensated based on their contribution to reliability—the supply of energy and reserves during periods of reserve shortage. Resources that expect to contribute nothing expect to receive nothing.

Q: Will some resources decide to operate in the market without a CSO?

A: The vast majority of operating resources will operate with a CSO. Existing resources typically are cost-effective because a large portion of their investment costs are sunk. Moreover, taking on the obligation at a level consistent with the unit's expected performance reduces risk. The unit receives a fixed payment for providing its share of performance during shortages and the unit's capacity provides a physical hedge for the obligation.

Nonetheless, there may be a few resources that prefer to operate in the energy market without a CSO. These typically will be resources with high cost, poor performance, or both. Consumers do not pay more as a result of these non-CSO resources. These resources are paid for any reliability they contribute at a rate consistent with the region's desired level of reliability, but they are not relied upon. Rather, the FCM will acquire efficient new capacity to replace the non-participating resources. Over the long-term, assuring reliability in this way still costs net CONE, since we assume the new entry market is contestable.

Q: How will the capacity price vary from year to year under PFP?

A: The capacity market under PFP is expected to have a more stable capacity price than today's market. The reason is that the market will clear at the expected cost of covering the share-of-system obligation during scarcity hours. The obligation has both real benefits for consumers and real costs for suppliers. The clearing price reflects these costs. The costs may change somewhat from year to year, but are largely invariant to whether there is excess supply in a particular year. Supply will exit or enter at the expected cost of the obligation.

In contrast, without PFP, the capacity price careens from near zero with excess supply to a high price when new entry clears. This increases risk and makes the market vulnerable to the exercise of market power on both sides of the market. As a result, without PFP the capacity price is a much less robust signal for investment incentives. Capacity price volatility has been and remains an important problem that has plagued capacity markets.

Q: Will the PFP design lead to excess entry?

A: No. The capacity market will select the most cost-effective resources up to the target that meets the Installed Capacity Requirement. Additionally, less cost-effective resources could decide to operate in the energy market despite not clearing in the FCA. These resources would be rewarded at the performance payment rate for energy or reserves supplied during scarcity hours. However, since they are less cost-effective than the cleared resources, they would lose money in expectation and decide to exit. Were they to stay in the market, then their contribution to reliability would reduce the number of scarcity hours, thereby further damaging their profitability. This market response to excessive entry drives the market back to the equilibrium where supply equals the Installed Capacity Requirement demand.

Q: How will PFP affect investment incentives?

A: With PFP, all resources face a strong marginal incentive to contribute to reliability by providing energy or reserves in scarcity hours. These strong incentives favorably influence all capital investments that improve performance during stressed system conditions, both in the short run and long run. Suppliers are motivated to make any cost-effective investment in reliability.

Q: How will PFP impact the mix of resources?

A: Favorably. PFP supplements the investment incentives provided by the energy and reserve markets with capacity payments that reflect a resource's contribution to reliability. These combined revenue streams motivate investment in a least-cost portfolio of resources system-wide. The portfolio will consist of a mix of resource types. When there are too few fast-start units, the value of a fast-start unit will be high and more fast-start units will enter. When there are too few baseload units, baseload units will have a high value and enter. Similarly, excessive reliance on one fuel type, such as gas, will increase the possibility of shortages from inadequate gas. This makes units that do not rely solely on gas more valuable and they will enter.

Without PFP, the resource mix suffers from adversely selecting less reliable resources, since contributions to reliability are not rewarded. As such, there are too few fast-start units and other resources that perform well in scarcity hours. The equilibrium result is a less reliable system that does not satisfy the reliability standard. The reliability shortfall could conceivably be addressed by purchasing additional capacity, but the purchase is not cost effective and might not actually address the problem if the new resources experience the same reliability shortcomings as the existing fleet (*e.g*. dependence on natural gas).

The correct solution is to adopt PFP. This properly rewards contributions to reliability, and thereby motivates investment in the least-cost portfolio for satisfying demand reliably.

VII. CONCLUSION

Q: Can you summarize the main elements of the PFP design and its implied long-run equilibrium properties?

A: Yes. PFP is based on two key elements. The first is a share-of-system supply obligation to provide energy or reserves during shortages. The second is a performance payment rate to settle deviations from the obligation. The performance payment rate is set equal to the net cost of new entry amortized over the expected number of scarcity hours that the resource provides energy or reserves. From these two elements we have the following long-run properties:

- The most cost-effective resources clear in the FCA; that is, the market selects the resources with the lowest cost per MWh of supply in scarcity hours.

- Entry occurs if capacity is needed to satisfy the Installed Capacity Requirement; exit occurs if there is surplus.

- The capacity price does not depend on whether there is excess supply. It remains at the net cost of new entry, which is equal to the expected cost of covering the supply obligation.

Q: Does this conclude your testimony?

A: Yes. This concludes my testimony.

I declare, under penalty of perjury, that the foregoing is true and correct.

Executed on January 17, 2014.

Peter Cramton