UNITED STATES OF AMERICA
BEFORE THE
FEDERAL ENERGY REGULATORY COMMISSION

ISO New England Inc.,) Docket No. ER02

AFFIDAVIT OF PETER CRAMTON[1]

I have been asked by ISO New England to comment on ISO New England's proposed changes to how the energy clearing price ("ECP") is calculated in the NEPOOL energy market. The changes are in response to recommendations made in the report by David B. Patton, *An Assessment of Peak Energy Pricing in New England During Summer 2001*, November 2001 (the "Patton Report"). The changes expand the conditions under which peaking units can set the 5-minute real time marginal price ("RTMP"), which is then averaged over the hour to determine the hourly ("ECP"). External contracts are brought into the same framework. The proposal is to implement these changes as soon as possible, likely second quarter of 2002, and then rely on them until the Standard Market Design ("SMD") is introduced, likely first half of 2003.

I conclude that the proposed changes have sound economic justification. The current rules potentially bias the ECP by not allowing certain flexible resources to set the ECP. The changes mitigate this bias by allowing these flexible resources to set the ECP. The potential bias is especially pronounced at times when the system is at or near capacity. It is at these times that the changes are likely to have the greatest impact in raising the ECP to the efficient level—a level that reflects the incremental cost of the last resource used to satisfy demand.

A potential concern is whether the changes aggravate incentives to exercise market power. A seller's exercise of market power biases the ECP upward. If the changes enhanced a seller's ability to exercise market power, then the changes might not be desirable. I address this concern and conclude that the changes do not appreciably enhance a seller's ability to exercise market power. My concern about market power is tempered by the fact that most generators in NEPOOL enter the energy market substantially hedged, limiting their incentive to exercise market power. Moreover, the current rules on market monitoring and mitigation provide at least some safeguard from market power abuses. On balance, I conclude that the changes are an improvement to current rules and should be adopted as soon as possible.

[1] Peter Cramton is Professor of Economics at the University of Maryland and President of Market Design Inc. Over the last 15 years, he has conducted research on auction theory and practice. This research appears in the leading peer-reviewed economics journals. During the last 7 years, Cramton has applied this research in the design and implementation of auction markets in the U.S. and abroad. He has led the design and implementation of several high-stake auction markets in the telecommunications and electricity industries.

1 Motivation for the Changes

The cornerstone of the electricity market is the energy clearing price. This is the most important price that market participants see. It is the basis for critical economic decisions by generators, load, and system operators. Roughly 20% of NEPOOL energy is traded at this price. It directly affects other prices such as spinning reserves, which are based on lost opportunity cost (ECP – energy bid) and capped at the ECP, and indirectly affects prices in bilateral markets. Hence, it is important to get the price right, or more realistically as close to right as possible.

In a simple world, all resources would be flexible. Then each resource could be dispatched up or down according to the economics. Efficient operation of the system would be trivial. The operator would rank the energy bids in merit order and move up the energy stack (from lowest to highest) until load is met. The ECP would be the bid for the last MW of electricity that is supplied. This price yields efficient production (energy is produced at least cost), and sends the right signal to load (reduced consumption is rewarded by the incremental cost savings it creates). With the ECP set in this way, all generation with offers below the ECP are generating energy to the extent they are able.

Unfortunately, actual electricity markets are not so simple. There are a number of factors that limit flexibility: start times, minimum run times, minimum down times, ramp rates, low operating limits ("LOLs"), reserve constraints, and transmission constraints. These constraints make operation of the system and determination of the right ECP highly complex. The basic principle in setting the ECP is that it should be based on the cost of incremental energy: what is the cost savings if one MW less of energy is consumed? Hence, a fossil unit operating at LOL is not eligible to set the clearing price. Since it is at LOL, its output cannot be reduced. The unit does not become flexible until it is operating at above LOL. A less expensive unit is backed down in response to a MW reduction in energy demand. This is the justification for the current NEPOOL rules that do not let any unit at LOL set the ECP. Likewise, other constraints, such as transmission constraints, which require units to operate even though they may not be in economic merit order, also make the unit ineligible to set the ECP. Ideally, these constraints would be reflected in the ECP through shadow prices from an elaborate dynamic optimization of the electricity system, but such an approach is not yet feasible.

Each of the units that is providing energy, but is ineligible to set the ECP, is potentially biasing the ECP downward. The energy from these constrained units effectively is treated as if the unit bid its block of energy at a price of zero. Hence, when determining the ECP, the operator does not need to march as far up the merit order as it would without the constraints, potentially setting a lower ECP. To mitigate this potential bias in the ECP, it is important to allow resources that are best viewed as incremental energy to set the clearing price. This is the motivation for the proposed changes in how the ECP is calculated.

The Patton Report makes two recommendations modifying how the ECP is set. First, allow all units committed intraday and dispatched at LOL in reserve shortage situations to contribute to setting the ECP. Second, allow peaking generators (generally gas turbines) to set the ECP when they are dispatched for reasons other than congestion relief or voltage support. In response to these recommendations, ISO New England has proposed rule changes to expand the circumstances under which a unit can set the RTMP. The first recommendation is addressed by a operating reserve criterion. It applies in situations of reserve shortage. The second

recommendation is addressed by two criteria, a spinning reserve criterion and an energy criterion. The spinning reserve and energy criteria apply to situations without an operating reserve shortage.

The criteria enable flexible resources to set the clearing price in certain situations. Flexible resources are defined throughout as peaking units and external dispatchable transactions. A peaking unit is defined as:

- Minimum run time ≤ 1 hour
- Minimum down time ≤ 1 hour
- Startup notification ≤ 30 minutes
- Dispatchable via RIGs

External dispatchable transactions are limited to 100 MW blocks at a single energy bid price. This restriction on block size reduces large swings in inter-control area schedules based on the acceptance of large blocks on an all or nothing basis. The restriction on block size also limits the ability to exercise market power. Peaking units and externals not eligible to set the RTMP will be eligible for net commitment period compensation ("NCPC").

I now discuss each criterion in turn.

2 Operating reserve criterion

The operating reserve criterion allows all flexible resources committed intraday and dispatched at LOL in reserve shortage situations to set the RTMP. A reserve shortage is defined as one where there are insufficient resources to satisfy energy plus total operating reserves (ten-minute spinning reserves ("TMSR"), ten-minute non-spinning reserves ("TMNSR"), and thirty-minute operating reserves ("TMOR")). In this circumstance, all peaking units and external dispatchable transactions are eligible to set the RTMP. Less flexible units typically would not be eligible to set the RTMP, since most of these units would have been committed day-ahead. Also, allowing such inflexible units to set the price would decrease market efficiency by setting artificial floors on the RTMP. Moreover, since the system is in a reserve shortage situation, the less flexible units that are able to run would already have been called and would be above LOL, unless constrained down to provide spinning reserve.

The proposal also limits when the ISO procures out of merit external transactions. Out of merit external transactions will only be accepted if they are needed to satisfy the operating reserves requirement (ten minute plus thirty minute reserve requirements). This gives the ISO sufficient reserves to satisfy the largest contingency.

The resources under this criterion are flexible and are committed and dispatched intraday. Each resource is contributing incremental energy to the system, and is needed to satisfy energy and essential reliability needs. Less expensive resources either are not available or are needed to provide reserves.

Some might argue that the resource really is needed for operating reserves and not energy, and thus should not be eligible to set the ECP. But in this shortage situation it is needed

for both energy and operating reserves. Even at LOL, it is providing needed incremental energy, and thus it should be allowed to set the ECP.

Under current rules, external dispatchable transactions already set the ECP via an external floor price in these circumstances. The change would be to evaluate the transaction on a five-minute basis, rather than on an hourly basis. The external dispatchable transaction would only set the price in the five-minute intervals that it is needed to satisfy energy plus operating reserves.

The most expensive peaking unit may be operating at LOL in order to provide energy and reserves. Under current rules, it is ineligible to set the RTMP. The operating reserve criterion recognizes that this unit is providing incremental energy and should be able to set the RTMP. (Even without a deficiency in operating reserves, this unit may be eligible to set the RTMP, according to the spinning reserve criterion discussed below.)

The operating reserve criterion only applies in extreme circumstances. Historically, these circumstances occur in only a handful of hours each year. Prices will be high in these hours, likely at or near the energy price cap of $1000.

One could argue that instances of reserve shortage are circumstances in which the market has failed. There are insufficient resources at any price to satisfy energy plus essential reserves. Hence, one cannot expect the market to determine the price. However, what the change does is reduce the possibility that the ECP is held down artificially. At these times, the price should reflect the high cost of incremental energy, which is at least as high as the most expensive peaker brought on line. When this price is at the energy price cap, then the price is not a market price, but a regulated price, ideally set at a sufficiently high level to encourage the development of price responsive demand.

The concern with this criterion is whether it encourages strategic behavior that increases the likelihood of reserve shortage situations. If this were the case, then the change at least in the near term would be counterproductive. It would have the consequence of *reducing* supply in near shortage situations, and thus reducing reliability.

I do not think that the operating reserve criterion creates much of an additional gaming opportunity for sellers of energy. First, in all but special circumstances, it would take a large withholding of capacity to throw the system into a reserve shortage situation. Doing so would only be profitable if the withholding generator has a large additional quantity of energy that it can sell at the energy price cap. Most generators are substantially hedged going into the real time market, so it is unlikely that a generator would find such a strategy profitable. If the system is already near shortage, then the energy and reserve prices likely are already so high that withholding enough to create a reserve shortage is unprofitable. Second, the generator can achieve the same result under the current rules by setting the external floor price (and hence the ECP) with a $1000 external transaction; hence, the rule change is unlikely to make matters worse. Third, the generator's behavior would be a violation of the "no withholding" rule. The behavior would be examined by the market monitoring process and mitigated if the high price was determined to be the result of strategic withholding. Market monitoring and mitigation is not a good excuse for allowing rules that are vulnerable to gaming; however, it is an important safeguard that limits market power abuse.

A seller of energy potentially can exercise market power by submitting a high-priced external transaction. The proposed rules have two safeguards that limit this problem. First, the external transactions are limited to 100 MW blocks, which prevents a seller from offering a huge external on an all-or-nothing basis. Second, an out of merit external transaction will only be accepted by the ISO once there is a shortage of thirty-minute operating reserves. Strategically putting the system into a state with insufficient thirty-minute operating reserves, rather than replacement reserves requires greater withholding of capacity. Hence, it is more likely that withholding capacity will be unprofitable—the economic cost of withholding often will be greater than the gain from receiving the higher price on the seller's remaining quantity.

3 Spinning reserve criterion

The spinning reserve criterion is used to determine if some of the online peaking units and external transactions were required to satisfy the TMSR requirement. If so, then these resources are eligible to set the RTMP. To determine whether the resource is needed, the Energy Market System calculates the excess TMSR as the actual TMSR minus the required TMSR. The online peaking and external resources are then stacked from lowest to highest energy bid. The highest priced resources up to a cumulative quantity no greater than the excess TMSR are ineligible to set the RTMP. All other peaking and external resources are eligible to set the RTMP.

The spinning reserve criterion is best seen in an example. Every five minutes the set of out of merit peakers and external transactions is evaluated as a final step in the five-minute SPD execution. Suppose that in this specific time interval:

- the RTMP from the previous SPD execution is $160,
- the Energy Market System has determined there is 210 MW of capacity online and available within 10 minutes in excess of the energy and spinning reserve requirements, and
- the LOL blocks of online peaking units and online external transactions are as in Table 1.

Table 1. Online peaker LOL and external transactions

Resource	Cumulative (MW)	LOL Block (MW)	Energy Bid ($/MW)
P1	10	10	200
ET1	110	100	190
P2	140	30	185
P3	170	30	180
P4	190	20	179
P5	205	15	179
P6	225	20	175
ET2	325	100	170
P7	350	25	165

Table 1 shows the LOL block of each online peaker (P1-P7) as well as all online external transactions (ET1-ET2). “Cumulative” is the cumulative total of the energy blocks, starting with the highest-priced block.

The spinning reserve criterion seeks to answer the question “Is this resource needed to create or preserve online reserve while meeting the energy requirements of the system?” Since there is 210 MW of excess TMSR, the highest-priced resources from Table 1 up to the 210 MW cumulative total are not needed for online energy and spin. Hence, the blocks P1 through P5 are not eligible to set the RTMP. However, blocks P6, ET2, and P7 are needed, and thus are eligible to set the RTMP. Hence, the RTMP is increased to $175, the highest-priced resource eligible to set the price. The RTMP can increase further as a result of the energy criterion, but it can not decrease.

Resources that pass the spinning reserve criterion (P6-P7) are flexible units providing incremental energy that is required by the system to satisfy online energy and reserve needs. Hence, these resources should be able to set the RTMP. The units priced above the last unit needed for energy plus spin (P1-P5) are flexible units providing incremental energy; however, these units are not needed by the system, and so they are not able to set the RTMP.

The criterion is limited to flexible units, since it is these units that are providing incremental energy, even when constrained to LOL. These units have short start times and run times. Hence, from an operators viewpoint they respond much like an online resource operating at above LOL. As soon as the unit is no longer needed to satisfy energy and reserves it is shut down. There is some lumpiness to both the external transactions and peakers at LOL, but the energy provided is still incremental.

One might argue that peaking units brought on to satisfy a reliability requirement not be allowed to set the energy price. However, the resource is brought on to jointly satisfy the energy plus spin requirement. The unit is needed for energy and is flexible, in that it can be quickly committed or decommitted. Hence, the energy provided by these units is best thought of as incremental energy. Although there may be less expensive energy resources on line, they are unavailable to provide energy, since they are needed to provide spin.

4 Energy criterion

The energy criterion determines if the LOL block of an online peaking unit or an online external transaction cannot be replaced by less expensive online energy. If so, then the resource is eligible to set the RTMP. The resource is providing incremental energy in merit, and therefore should be able to set the RTMP.

To continue the example from the previous section, suppose that in this specific time interval:

- the RTMP from the previous SPD execution is $160 (before the spinning reserve criterion),
- the LOL blocks of online peaking units and online external transactions are as in Table 1, and

- the online energy blocks other than the LOL of peaking units and external transactions are as in Table 2.

Table 2 shows all other online energy blocks (OL1-OL9) above the tentative RTMP of $160, including peaker blocks above LOL, which are available in 5 minutes. Multiple blocks available in 5 minutes from the same resource are listed separately (OL2a and OL2b). "Cumulative" is the cumulative total of the energy blocks, starting with the lowest-priced block.

The energy criterion seeks to answer the question "Is the peaker LOL or external transaction needed for energy in the sense that it cannot be replaced by less expensive online energy available within 5 minutes?" The resources listed in Table 2 represent the candidate replacements of the peaker LOLs and external transactions. To answer the question, we march up Table 2 as we march down Table 1, replacing the most expensive peaking LOLs and external transactions with less expensive online energy resources. We do this until a peaker LOL or external transaction cannot be replaced by a less expensive online resource. In this case, replacing P6 at $175 requires 225 MWs of energy, which can be done with units up to OL8 at $174. However, the next resource in Table 1 is ET2 at $170, requiring 325 MWs of energy. This resource can only be replaced by OL9 at $400. Hence, resources ET2-P7 are needed for energy, and are able to set the RTMP. This would yield a RTMP of $170. Since this is less than the price from the spinning reserve criterion, the RTMP is set by resource P6 operating at LOL at $175.

Table 2. Online energy other than peaker LOL and external transactions

Energy Bid ($/MW)	Size (MW)	Cumulative (MW)	Resource
400	50	360	OL9
174	100	310	OL8
173	30	210	OL7
171	30	180	OL6
170	50	150	OL5
166	20	100	OL2b
165	15	80	OL4
164	25	65	OL3
163	20	40	OL2a
161	20	20	OL1

The energy criterion lets flexible resources—peaking units and external transactions—set the RTMP if they are "in merit" for energy in the sense that there are not other less expensive online resources that could replace them. Flexible resources that can be replaced by other online resources in 5 minutes are not able to set the RTMP. These resources, although providing energy, are not providing incremental energy. If these units were truly flexible, the operator would replace their energy with less expensive blocks from other online resources.

5 Conclusion

ISO New England has proposed three changes to the way the energy clearing price (ECP) is calculated. These changes expand the set of resources that are eligible to set the 5-minute real

time marginal price (RTMP), which is then averaged over the hour to determine the ECP. The changes are summarized in three criteria:

- *Operating reserve criterion*: When there are insufficient resources to satisfy energy plus total operating reserves, all flexible resources committed intraday and dispatched at LOL are eligible to set the RTMP.
- *Spinning reserve criterion*: Online peaking units and external transactions that are needed to satisfy energy plus ten-minute spinning reserve are eligible to set the RTMP.
- *Energy criterion*: Online peaking units and external transactions that cannot be replaced by less expensive online resources in five minutes are eligible to set the RTMP.

The economic justification for each of these criteria is strong. In each case, the resources are providing incremental energy, which is needed to satisfy energy and reserves. On economic grounds these resources should be eligible to set the clearing price. The operating reserve criterion raises a potential concern about the exercise of market power; however, it does not significantly enhance a participant's ability to exercise market power from what can be done today. Hence, I recommend that the three criteria be adopted as soon as possible. All three represent improvements in the way the energy clearing price is determined.

ATTESTATION

I am the witness identified in the foregoing affidavit. I have read the affidavit and am familiar with its contents. The facts set forth therein are true to the best of my knowledge, information, and belief.

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Peter Cramton

February 26, 2002

Subscribed and sworn to before me
this 26 day of February, 2002

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Notary Public

My commission expires: _____