ISO new england

memo

To: NEPOOL Markets Committee ("MC")

From: Market Development

Date: December 1, 2021 (*with minor revisions 12/6/2021*)

Subject: Concerns with LS Power's Proposal

At the November 9, 2021 MC meeting, LS Power, on behalf of Jericho Power, presented a revised proposal for a system of financial transfers among suppliers based on resources' performance when real-time reserve prices are positive. Upon review, this proposal would have deleterious consequences for the efficiency of real-time dispatch and generators' dispatch-following incentives. The ISO considers these serious flaws with the proposal. For these reasons, as explained further in this memorandum, the ISO opposes the present LS Power proposal.

Context. In brief, LS Power proposes to create a new set of credits and charges among resource owners that is modeled, in significant part, on the current Pay for Performance (PFP) design.[1] One key difference between the PFP design and LS Power's proposal is when performance is assessed. Stated simply, the PFP design assesses performance only when there is a real-time violation (i.e., a shortage) of a minimum real-time reserve requirement (known as a Capacity Scarcity Condition, or CSC). LS Power's proposal would create a new, additional set of credits and charges whenever there is a positive real-time price for reserves but no CSC (as PFP would continue to apply in any CSC).[2]

LS Power proposes to credit or charge each resource for its actual performance (energy and reserves supplied) during positive reserve price (but non-CSC) intervals, relative to a resource's balancing-ratio adjusted Capacity Supply Obligation, at a new rate of $350 per MWh. We note that no derivation or precise rationale for that proposed rate is put forth in LS Power's materials, though the appropriateness of that proposed rate is not the central concern of this memorandum.

Problems and Concerns. The ISO has two primary concerns with the present LS Power proposal:

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[1] This assessment is based on LS Power's Nov. 9, 2021 presentation, available at https://www.iso-ne.com/static-assets/documents/2021/11/a03c_ii_2021_11_09_10_jericho_power_presentation_ccm_without_mopr.pdf, and the Committee's discussion of same. Subsequent revisions to LS Power's proposal may alter the applicability of the concerns in this memorandum.

[2] There is a (correctable) ambiguity in the LS Power proposal, in that the reserve price stated in LS Power's Nov. 9, 2021 presentation and proposed Tariff changes does not correspond to an actual Real-Time reserve price currently in use. This ambiguity is peripheral to the specific concerns in this memorandum, however.

1. It creates financial incentives for resource owners to offer in the real-time energy market at offer prices below their true marginal cost; and
2. It creates financial incentives for resources to not follow their assigned real-time dispatch instructions (specifically, to produce energy in excess of real-time dispatch instructions).

These concerns arise under LS Power's proposal because the marginal and extra-marginal resources that have unloaded capability (whether online or fast-start) above their combined energy dispatch and reserve designations can financially benefit from 1) reducing their offer prices to increase their energy dispatch instruction, and/or 2) directly increasing their energy output (above their dispatch instruction). Either behavior will increase the resource's measured performance and revenue during events when performance is assessed under the LS Power proposal, yet undermine dispatch efficiency and/or the system's power balance.

These concerns have practical consequences. The first problem undermines the least-cost objective of efficient real-time dispatch: offer prices would no longer reflect resources' actual marginal costs, changing the dispatch solution and increasing total production costs, in general. Further, the first problem also undermines one of the fundamental desirable properties of competitive, Locational Marginal Price-based markets: to accurately signal the marginal cost of serving incremental energy demand. The second problem creates potential operational concerns, as it can have a number of deleterious consequences for real-time system performance.[3]

PFP is not similar. Importantly, the current PFP design does not create these problems. The reason is subtle and technical, but important. When a minimum reserve requirement is violated in real-time, the real-time dispatch solution will set all resources' combined energy and reserve MW to the maximum each resource can provide, and every resource's combined energy and reserve instruction will be binding on a constraint (e.g., the unit's EcoMax, or its ramp rate limit, or a network constraint, and so on). In effect, in a Capacity Scarcity Condition, the physical capability of each unit available to the real-time dispatch optimization is fully utilized; there is no 'headroom' for any resource to increase its output to improve its performance. (That property is precisely why the system experiences a real-time reserve shortage.) Because *every* resource's combined energy and reserve MW is constrained by some limit during a CSC (and only during a CSC), the current PFP design does not create the problems identified with the LS Power proposal.

Details. In an earlier, October 21, 2021 presentation to the MC, LS Power stated that because its proposal measures resource performance using "the same criteria that is used in PfP - i.e., resources providing either energy, 10-minute OR [Operating Reserve], or 30-minute OR, . . . resources would remain indifferent and would not have an incentive to ignore dispatch instructions."[4] However, with all due respect, LS Power is incorrect in this assumption. In the Appendix to this memo, we provide numerical examples that show precisely how the LS Power proposal creates the two problems discussed above. The

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[3] These include excess Area Control Error (ACE), excessive costs for regulation service used to correct ACE, inadvertent power flows to neighboring Balancing Authority Areas, or combinations thereof.

[4] Slide 19, available at https://www.iso-ne.com/static-assets/documents/2021/10/a02a_i_mc_2021_10_21_jericho_power_draft_proposal.pdf.

Appendix examples also show why the same concerns do not arise under the existing, FERC-approved PFP design.

Summary and Broader Issues. We emphasize that our concerns with the present LS Power proposal are narrow. LS Power motivates its proposal, stated broadly, in terms of creating incentives for investment in resource flexibility and reliability. As a general matter, these are desirable goals and worthy of continued discussion, particularly as New England transitions to a power system that is increasingly dependent on "just in time" input energy sources that may not be able to perform when there they have insufficient oil or gas, or when the wind and sun are not conducive to renewable resources' production. We are also cognizant that the New England system, given its excess supply conditions and the generally strong performance of the generation fleet in recent years, has experienced few real-time reserve shortages since PFP was implemented in 2018. For these and the reasons covered in greater detail in the Appendix to this memorandum, addressing incentives for resource flexibility in this environment will, in all likelihood, require more involved market design efforts than the proposed "extension" of PFP put forth by LS Power.

We hope the Committee finds this memorandum, and the detailed examples provided in the Appendix, to be informative and to facilitate productive discussion of these broader issues.

Appendix

In this Appendix we present simple, four-generator numerical examples of co-optimized real-time dispatch solutions and prices. We use these examples to explain three central points:

1. When the system is not in a real-time reserve shortage, the LMP and Reserve Clearing Price (RCP) provide correct marginal incentives to resources: No resource has an incentive to deviate from its dispatch instruction, or to offer below its marginal cost.
2. In contrast, the present proposal by LS Power would create adverse incentives for resources to deviate from their dispatch instructions, or to offer below marginal cost.
3. The existing Pay for Performance design, which applies only during real-time reserve requirement violations (and for that reason), does not suffer from either of the adverse problems identified with the LS Power proposal.

The Appendix closes with some useful insights about why these properties hold generally.

General Assumptions

To focus on key points, we assume for simplicity there are no transmission constraints, no energy losses, a fixed real-time energy demand, and a single reserve requirement/reserve product. We consider real-time dispatch solutions, taking the unit commitment as fixed. When convenient for totaling costs and listing designations, we will assume a study period of one hour. The Reserve Constraint Penalty Factor (RCPF) is assumed to be $1,000/MWh.

Resource Characteristics, Load, and Reserve Requirement

We consider four generators in the examples, numbered G1 though G4. Their characteristics and offers are presented in the table below:

Table 1- Resource Characteristics

Generator	*Reference*	Offer Price $/MWh	EcoMin MW	EcoMax MW	Ramp Rate MW/min	10-Min Ramp Capability MW
G1	*Big, fast, cheap*	$45	0	260	4	40
G2	*Small, slower, expensive*	$48	0	40	2	20
G3	*Small, slower, but cheapest*	$42	0	60	2	20
G4	*Big, slow, and most expensive*	$50	60	180	1	10
Totals			**60**	**540**	**9**	**90**

We will assume the single reserve requirement and product in these examples is 10-minute reserves, which is simpler to model and evaluate in numerical examples than a 30-minute reserve requirement (which technically incorporates, and therefore must also model, 10-minute ramp capability). The conclusions throughout this Appendix would also hold with a (suitably modified) model using both 10-minute and 30-minute reserves, or just the latter. Note also that in the last column of Table 1 we show each generator's total 10-minute reserve capability, which will be useful to compare with their reserve designations in upcoming examples.

Scenarios Studied

Throughout the examples, assume real-time energy demand is 455 MWh. We will consider two cases:

- In Example 1 with positive reserve pricing (but no CSC), the reserve requirement (RR) is **69 MW**
- In Example 2 with a reserve shortage (a CSC), the reserve requirement will be higher, at **91 MWh**.

We evaluate and compare generators' profits for three possible actions, each in turn: (1) if generators offer at marginal cost and follow dispatch instructions; (2) if generators offer at marginal cost, but (some) produce more energy (deviate from) dispatch instructions, and (3) if (some) generators offer below marginal cost, and all follow their (new) dispatch instructions.

Example 1: A Dispatch with Positive Reserve Prices (But No Reserve Shortage)

This example considers a case where LS Power's proposed transfers would be triggered, but the current PFP mechanism is not.

With load at 455 MWh and a reserve requirement of RR = 69 MWh, the least-cost, cooptimized dispatch solution is provided in the table below, assuming each generator offers at its marginal cost.[5] The final two columns show each generator's total production cost and total profit.

Table 2 - Market Outcomes in Example 1 with Resources Offering at Marginal Cost

Generator	Offer Price ($/MWh)	Energy (MWh)	Reserves (MWh)	Total Cost ($)	Profit ($)
G1	$45	221	39	$9,945	$1,300
G2	$48	20	20	$960	$140
G3	$42	60	0	$2,520	$480
G4	$50	154	10	$7,700	$50
Shortage	N/A	0	0	N/A	N/A

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[5] The optimal dispatch solution and market clearing prices to each example herein can be obtained as the solution to a linear programming problem to minimize total cost (the technical formulation of which is straightforward and omitted).

The marginal generator is G4, so the LMP is **$50/MWh.** Reserves are optimally carried on the most expensive resources (here and generally), but G4 has no additional reserve capability (its ramp limit provides only 10 MWh of reserves). Therefore, and increment of additional reserves would be most cost-effectively procured by re-dispatching G3 down for energy by 1 MWh, and re-dispatching G4 up for energy by 1 MWh. The incremental cost of that redispatch to serve an increment of reserves is $50 – $45 = $5/MWh, and therefore the Reserve Clearing Price (RCP) is **$5/MWh.**

In this example, and quite generally when the system is not in a reserve shortage, not all generators are fully "loaded" (i.e., not all of their achievable capability is designated for either energy or for reserve). In particular, G4's combined energy dispatch and reserve designation is 164 MWh, leaving 16 MWh that is not designated for energy or reserve. This key point appears in the following unit "loading" graph, which is simply a graphical representation of the dispatch solution for each generator in Table 2. Here each bar height is a generator's EcoMax (in MW), yellow shading denotes its reserve designation, dark green is its energy above EcoMin, light green is energy below EcoMin, and white space indicates unloaded, undesignated capacity:

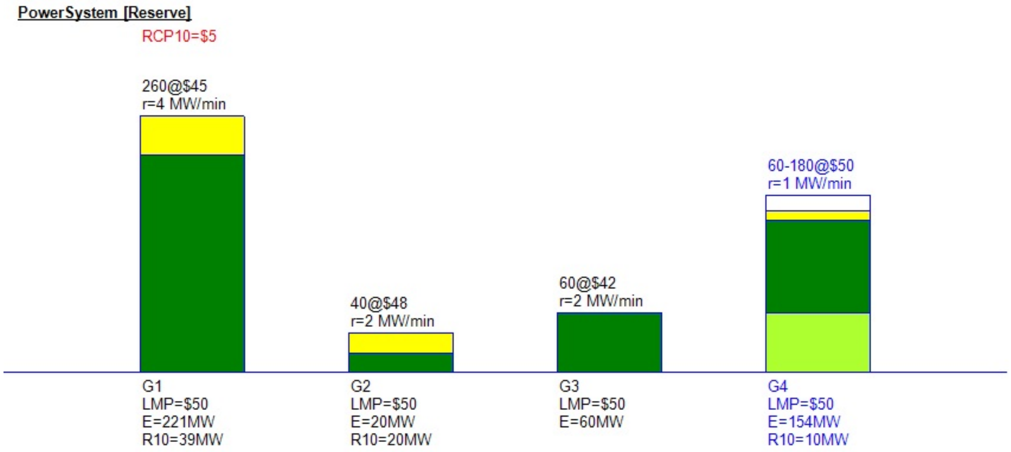

Figure 1. G4 has unloaded, undesignated capability.

For convenient reference, above each generator in Figure 1 are shown the assumed values of its offered capability and offer price, and its ramp rate, from Table 1. And under each generator in Figure 1 we show the generator's energy (E) dispatch, and its reserve (R10) designation, from Table 2.

No Incentive to Deviate from Dispatch Under Current Market Rules

It is straightforward to observe that without any additional payments (as would occur under the LS Power proposal), no resource has incentive to deviate from the ISO's least-cost dispatch instruction. Three of the four generators (G1 though G3) have no undesignated capability, and any increase in G1 or G2's energy output would reduce their reserve revenue ($5/MWh) by an amount equal to or greater than their respective energy margins ($5/MWh for G1 and $2/MWh for G2).

Marginal generator G4 is not similarly physically limited in the dispatch solution. However, if G4 produces energy in excess of its dispatch instruction by (say) 6 MWh, so that its energy output is 160 MWh instead of ISO's dispatch instruction of 154 MWh (per Table 2), then G4 will not earn any additional profit from its additional energy output (as its marginal cost is equal to the LMP, both at $50/MWh). And at an additional 6 MWh of energy output it would continue to have the same ramp range of 10 MWh and therefore continue to provide (and be compensated at the RCP for) 10 MWh of reserves. As a result, G4's profit from the provision of reserve also does not change if G4 deviates by (say) 6 MWh from its energy dispatch.

Key Point 1: When the system is not in a real-time reserve shortage, the LMP and Reserve Clearing Price (RCP) provide no incentive for a resource to deviate from its dispatch instruction. This illustrates the first point enumerated at the outset of this Appendix.

Incentive to Deviate from Dispatch under the LS Power Proposal

Under the LS Power proposal, additional payments and charges would be triggered anytime the RCP is greater than zero, as occurs in Example 1. In these conditions, LS Power proposes that resources receive $350 for each additional MWh (in the form of a credit or a reduced charge) for their Actual Capacity Provided (ACP). ACP is a concept that is borrowed from PFP, and is simply a resource's energy and reserve provided.

We next calculate the proposed payment to G4 when it follows the ISO's dispatch correctly, and when it deviates from its dispatch instruction. If it follows its dispatch instruction, G4's total energy and designated reserve is 164 MWh (see Table 2), and it will receive the following additional credit for its ACP under the LS Power proposal:

ACP × $350/MWh = [154 MWh (energy) + 10 MWh (reserve)] × $350/MWh = **$57,400.**

Suppose, however, that G4 deviates from its dispatch, by producing (again say) an additional 6 MWh, so that its total energy output is 160 MWh. At this energy output level, it still provides 10 MWh of reserve capability (as discussed previously), and it will receive the following additional credit for its ACP under the LS Power proposal:

ACP × $350/MWh = [160 MWh (energy) + 10 MWh (reserve)]× $350/MWh = **$59,500.**

Note that to these ACP payments, a debit would then be applied based on G4's adjusted CSO MW (using the Capacity Balancing Ratio, another concept the LS Power proposal adopts from PFP). However, that debit is the same regardless of G4's actual performance or its dispatch. Therefore, it can be ignored in evaluating G4 incentives; with or without the balancing-ratio-based debit, G4 is better off financially – by $2,100 – if it deviates from its dispatch. And if it deviates by more than the 6 MWh assumed here, it would be even better off financially under the LS Power proposal. The incentives have gone awry.

Key Point 2(a): The marginal generator G4 will earn $2,100 more, under the LS Power proposal, if it deviates from its instructed dispatch. Thus, it is being put into a position where its financial incentives run directly contrary to following its dispatch instructions, and here the total energy output in the system exceeds the correct amount to balance energy demand. This illustrates the second main point enumerated at the outset of this Appendix: The LS Power would create adverse incentives for resources to deviate from their dispatch instructions.

It is important to note that this adverse incentive problem is true generally for both the marginal generator(s) in real-time, *and* for any extra-marginal (online or fast-start) generators, that have unloaded, undesignated capability in the dispatch solution. In practice, there can be dozens (or more) such extra-marginal generators operating when real-time reserve prices are positive (but the system is not in a reserve shortage). Thus, in the real power system, this problem would not limited to the incentives facing a single marginal generator.

Incentive to Offer below Marginal Cost Under the LS Power Proposal

While there are many possible amounts a resource could lower its offer price to below marginal cost, for concreteness we evaluate the change in G4's profit if it is offers at $40/MWh instead of its true marginal cost of $50/MWh. (The general point that follows would also hold for different values). With a lower offer price, the dispatch solution will change, and the LMP, RCP, and quantities can change. We have recomputed the optimal dispatch solution when G4's offer price is $40/MWh, and provide the results in Table 3 below. Now G3 is the marginal unit, the LMP is $48/MWh, and the RCP is $6/MWh. We highlight the market results for G4 in red here, as they will be our next focus.

Table 3 - Market Outcomes if G4 offers at $40/MWh, below its Marginal Cost of $50/MWh

Generator	Offer Price ($/MWh)	Energy (MWh)	Reserve (MWh)	Cost as Offered ($)	True Total Cost ($)	Profit ($)
G1	45	220	40	$9,900	$9,900	$900
G2	48	4	20	$192	$192	$120
G3	42	51	9	$2,142	$2,142	$360
G4	40	180	0	$7,200	$8,640	-$360
Shortage	N/A	0	0	N/A	N/A	N/A

In this table, we calculate in the second-to-last column G4's true total cost based on its true marginal cost of $50/MWh. Note that, as shown in the last column, G4 is losing money in the energy and reserves market if it offers below cost at $40/MWh. For this reason, under current market rules, G4 has no incentive to offer below its marginal cost (reinforcing again Point 1 from the outset of this Appendix).

But, with the LS Power proposal, that is not the whole story….

Since the reserve price is $6/MWh, LS Power's proposed additional ACP payments are is triggered here. G4's additional ACP payment when it offers truthfully (at its $50 marginal cost) was calculated in the previous section, and is **$57,400.** Now compare that amount with its ACP payment when G4 offers below its marginal cost at $40/MWh:

ACP × \$350/MWh = [180 MWh (energy)] × \$350/MWh = **\$63,000.**

In sum, G4 makes (\$63,000 - \$57,400 =) \$5,600 more in additional ACP payments, under the LS Power Proposal, when it offers below its true marginal cost. Note that G4's additional \$5,600 ACP payment (by offering below MC) is more than sufficient to cover its \$360 loss in the energy market by doing so (see Table 3), thereby returning a sizeable profit of \$5,600 – \$360 = \$5,240 by offering below cost.

Key Point 2(b): The marginal generator G4 will earn \$5,240 more, under the LS Power proposal, if it offers below its true marginal cost. Thus, it is being put into a position where its financial incentives run directly contrary to offering consistent with competitive market fundamentals (*viz.,* at a price equal to marginal cost). This again illustrates the second main point enumerated at the outset of this Appendix: The LS Power would create adverse incentives for resources to offer below marginal cost.

Importantly, this incentive problem can spiral out of control, a more subtle implication of the LS Power proposal that is nonetheless evident even in this simple 4-generator model. Specifically, inspection of the dispatch solution in Table 3 reveals that another unit, G2, now is in the position of having some 'headroom' in the new dispatch solution when G4 offers below its marginal cost. Because of this, G2 too now has a financial incentive to deviate from its dispatch instruction (the analysis is similar to the previous section). That is, the problem of one unit acting on the adverse incentives of the LS Power proposal 'compounds' to adversely affect the incentives of other generators as well.

Last, note that the LMP has declined in the dispatch solution of Table 3 from that in Table 2. For that reason alone, all generators are potentially adversely impacted by these improper incentives (the proper energy market price formation in a competitive market, where prices should reflect marginal cost, is undermined generally).

Example 2: A Dispatch with a Reserve Shortage

In this next example, we show why the current PFP design does not create the two adverse incentive problems that we have identified with the LS Power proposal. In this next example there will be a reserve shortage, so a Capacity Scarcity Condition will trigger PFP payments. However, no payments related to LS Power's proposal (as proposed) are triggered under reserve shortages.

For convenience, in this example we use the same set of resources as Example 1. The only difference in Example 2's assumptions is to assume a higher reserve requirement, of 91 MWh. This will result in a reserve shortage. Specifically, the system needs a minimum of 546 MWh to serve a 455 MWh energy load and 91 MWh of reserve requirement. The sum of all resources' capabilities (sum of all EcoMax values of the four generators) is only 540 MWh, however. Thus, we know we will observe a reserve shortage even before solving for the co-optimized dispatch solution.

In Table 4 below, we show the co-optimized dispatch solution assuming all resources offer at their marginal cost, and with the new reserve requirement of 91 MW. Because there is a reserve shortage, the RCP is set by the RCPF of \$1,000/MWh. The system has a 6 MWh shortage of reserves. The LMP in this example is \$1,042/MWh, and G3 is the marginal generator for energy.

Table 4 - Market Outcomes in Example 2

Generator	Offer Price ($/MWh)	Energy (MWh)	Reserves (MWh)	Total Cost ($)	Profit ($)
G1	$45	220	40	$9,900	$259,340
G2	$48	20	20	$960	$39,880
G3	$42	45	15	$1,890	$60,000
G4	$50	170	10	$8,500	$178,640
Shortage	N/A	0	6	N/A	N/A

Figure 2 below shows the optimal unit loading graph for the system corresponding to Table 4 in this reserve shortage. The key point to note here is that the system as no 'headroom' on any unit. That is, each unit's combined energy and reserve MWh are binding on a (unit-specific) physical constraint – here, each unit's EcoMax, and for G1, G2, and G4, reserves are also limited by (binding on) their ramp rates. Thus, it is not possible to achieve any additional (combined) energy and reserve from any resource.

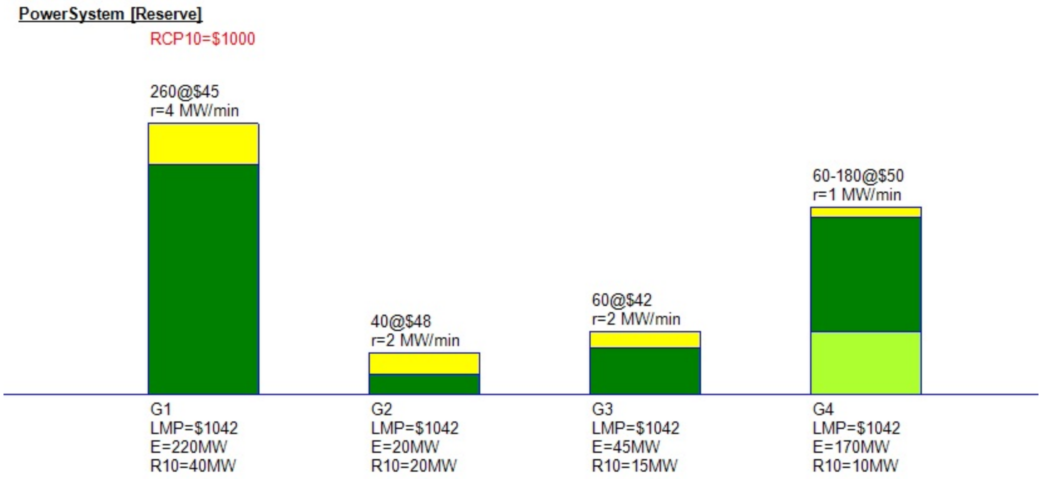

Figure 2. The system has no slack in a reserve shortage

In this example, the reserve price is equal to RCPF and the RCPF is incorporated into the LMP. This is the trigger (in simplified terms) for a Capacity Scarcity Condition under PFP. In this example, the Actual Capacity Provided (ACP) is equal to EcoMax for each unit.

No Incentive to Deviate from Dispatch

We now consider resources' incentives under PFP. For these purposes, the Performance Payment Rate (PPR) under PFP is assumed to be $9,000/MWh (the conclusions below would be unchanged with a different PPR value, within broad limits).

Consider the incentive to deviate from dispatch for G4. (The analysis is similar for the other units). Generator G4 is loaded for energy and designated for reserves (combined) to its EcoMax. Because of this, if it increases its energy output, its reserve performance will be lower 1-for-1. It faces the following tradeoff:

- **Gains from higher energy output:** 1 MWh more in energy output will bring $1,042/MWh more in energy revenue and $9,000/MWh more in PFP payments for ACP, but costs generator G4 another $50/MWh for fuel, an overall gain of $9,000 + $1,042 – $50 = **$9,992**.
- **Losses from lower reserve output:** 1 MWh less of reserves will lower G4's real-time reserve payment by the RCP of $1,000/MWh and its PFP payment for ACP by $9,000/MWh. An overall loss of **$10,000**.

Put together, generator G4 loses $8 if exceeds the ISO's dispatch instructions by 1 MWh, so it does not have any financial incentive to do so. G4 is loaded (for energy and reserves combined) to its maximum, but G4 is *not indifferent between providing energy or reserve.* Both are highly profitable at the prevailing market prices, but G4 prefers to sell more reserve than energy. The problem is that it is at its maximum reserve designation of 10 MWh, and its physical ramp rate limits its ability to sell any additional reserve.

This analysis can be extended (in a straightforward way) for all of the other generators in this example, with the same conclusion. No resource has an incentive to deviate from its dispatch, as each resource's combined energy dispatch and reserve designations are bound by one or more (physical) constraints during a real-time reserve shortage.

No Incentive to Offer Below Marginal Cost

Similar to Example 1, now consider the outcomes in Example 2 if generator G4 offers at a price below marginal cost at (say) $40/MWh, instead of offering at G4's true marginal cost of $50/MWh. The lower offer price will again change the co-optimized dispatch solution and the LMP. Table 5 below summarizes the optimal dispatch solution in this situation. Here the LMP is $1,040/MWh, which again is lower than the LMP in Table 4 when G4 offers at its true marginal cost. The RCP remains unchanged at $1,000/MWh because there continues to be a reserve shortage (there is insufficient capability to meet total load and the reserve requirement in Example 2, as before).

Table 5 - Market Outcome in Example 2 when G4 offers at a price below Marginal Cost

Generator	Offer Price ($/MWh)	Energy (MWh)	Reserve (MWh)	Total Cost as Offered ($)	True Total Cost ($)	Profit ($)
G1	$45	220	40	$9,900	$9,900	$258,900
G2	$48	20	20	$960	$960	$39,840
G3	$42	40	20	$1,680	$1,680	$59,920
G4	$40	175	5	$7,000	$8,750	$178,250
Shortage	N/A	0	6	N/A	N/A	N/A

At the optimal dispatch solution in Table 5, all units are still loaded (for energy and reserves combined) to their maximums and the system again has no 'headroom' on any unit. For G3 and G4, the dispatch and reserve designations are different, however. Generator G4's energy is now offered at a lower price than G2 or G3's energy, and dispatch optimization will assign it to produce more energy and provide less reserve than when G4's offer price was equal to its marginal cost; *c.f.* with Table 4.

But providing more energy and less reserve is the *opposite* of what maximizes G4's profit. As noted above, for generator G4, providing reserve is more profitable (per MWh) than producing energy (per MWh). The resulting drop in G4's profit is observable in the final column of Table 5 in comparison to Table 4 for G4; though it profits in both situations, it does worse in Table 5, when it offers below its marginal cost. Here, note that G4's PFP payments are unchanged, because in both cases G4's ACP (combined energy and reserve MWh) is the same, at 180 MWh (its EcoMax). But G4's energy and reserve market profit is less, and, as a result, it has no financial incentive to offer below its marginal cost.

Key Point 3: In a CSC under PFP, generator G4 will earn less if it deviates from its dispatch instruction, or if it offers energy below its true marginal cost. This is true of the optimal dispatch generally under PFP, because in a real-time shortage of a minimum reserve requirement, the unit dispatch system will fully utilize all available capability of every dispatchable unit (i.e., every unit's combined energy dispatch and reserve designation will be binding on one or more constraint(s) in the dispatch solution). This illustrates the third main point enumerated at the outset of this Appendix: The existing Pay for Performance design, which applies only during real-time reserve shortages (and for this reason) does not suffer from either of the adverse incentive problems identified with the LS Power proposal.

A few final insights and observations

The key difference between PFP and the LS Power proposal that drives these different incentive problems is the conditions in which the additional performance payments are triggered. Additional performance payments change marginal incentives (significantly), and therefore can have substantial unintended market impacts unless they are designed very carefully.

To be clear, the ISO's design teams were cognizant of, and carefully studied, these issues when PFP was originally designed. In fact, the examples in this Appendix were originally developed at that time to study these same effects, in both simple models (as shown here) and to confirm and understand the same properties when the ISO tested PFP to examine these issues using larger-scale dispatch simulations. The only practical means to change the frequency of PFP-triggering events without creating similar adverse problems (similar to the LS Power proposal's) would be to increase the real-time reserve requirements, as is illustrated by comparing the dispatch solutions in Example 1 versus Example 2.

In summary, PFP is triggered *only* when the system is experiencing a true shortage of reserves and no resource can provide more (combined) energy and reserve. It is indeed *because* resources cannot do anything to increase their ACP that increasing their marginal incentives by the PPR value does not distort their financial incentive to offer at marginal cost and to follow the ISO's dispatch instructions during a CSC.

In contrast, the LS Power proposal is triggered when system 'redispatches' energy to create additional reserve in order to satisfy the system's reserve requirements. As we observed in Example 1, this could happen in a situation where the system has plenty of slack (additional 'headroom' and/or reserve capability), and some resources can generally increase their revenues (ACP payments under the LS Power proposal) in response to the increased marginal incentive (the $350/MWh adder). The most simple ways to increase a resource's ACP in such situations are to exceed the ISO's dispatch instruction or to offer at a price below marginal cost. The LS Power proposal creates incentives to do both.