REPORT

Millstone Nuclear Power Plant

Estimated Cost to Exit
Capacity Supply Obligations

Prepared for: Electric Power Supply Association

Prepared by: Energyzt Advisors, LLC

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1. INTRODUCTION

In April 2017, Energyzt performed a financial assessment of the Millstone Nuclear Power Plant that concluded the plant had been profitable and was projected to continue to be profitable in the future based on publicly-available price projections.[1]

In June, Dominion Resources, Inc. (Dominion) indicated that it was undergoing a strategic assessment regarding Millstone and issued a letter to ISO-New England (ISO-NE) requesting clarification of the options to retire for economic reasons. ISO-NE's reply indicated that Millstone was obligated to remain operational through May 2021 under its tariff-based Capacity Supply Obligations (CSO) and through May 2022 as a result of Dominion's decision not to submit a retirement de-list bid to ISO-NE by the March 24, 2017 deadline. However, Dominion has the option of buying out of its obligations committed under the Forward Capacity Auctions (FCAs) through ISO-NE reconfiguration auctions or bilateral arrangements, subject to a reliability review.[2]

This paper presents an estimate of what it would cost Dominion to shed its CSOs via ISO-NE Annual Reconfiguration Auctions (ARAs). Under the analytical approach described below, the estimated cost to Dominion to buy out of its existing Millstone CSOs for the period June 2018 through May 2021 would be around $680 million.[3] Additional costs would be incurred to buy out of the capacity commitment that Millstone will take on in the upcoming FCA 12, as the company did not submit a retirement de-list bid for Millstone in March 2017. Under conservative assumptions, the combined cost to buy out of its capacity commitments could

[1] Energyzt, "Financial Assessment: Millstone Nuclear Power Plant," April 2017, https://epsa.org/wp-content/uploads/2017/05/4250100000005.filename.ENERGYZT_Assessment_of_Millstone_201704_FINAL.pdf

[2] "Dominion has the option to seek to transfer these obligations through bilateral agreements or through demand bids (i.e., bids to shed a CSO) in reconfiguration auctions held by the ISO in advance of the relevant Capacity Supply Commitment Periods," Letter from ISO-NE to Thomas P. Wohlfarth, Senior Vice President – Regulatory Affairs, Dominion Resources, Inc., June 23, 2017, http://www.ctnewsjunkie.com/upload/2017/06/ISOResponse_to_Dominion_Letter.pdf

[3] Dominion would incur additional costs to buy-out of its anticipated 2021-2022 CSOs, which could be substantial, but are outside the scope of this analysis.

approach $1 billion, nearly the total that Dominion paid to acquire the Millstone plants in 2001 from Northeast Utilities.[4]

2. Methodology

Estimating the cost to shed a CSO in an ARA requires estimating the clearing price in the ARA assuming a Millstone withdrawal times the CSO. The analysis assumes that the corresponding capacity demand curve in each ARA will set the price. As a cross-check and confirmation, market bids and offers from prior ARAs were compared to the assumptions and analytical results.

ISO-NE performs FCAs on an annual basis roughly forty months in advance of when capacity resources are required. Starting a year after the FCA, ISO-NE manages capacity reconfiguration auctions on an annual and monthly basis in order to allow demand and supply resources to adjust their FCM obligations. Figure 1 provides the schedule for upcoming ARAs.

Figure 1: ARA Opening Dates

FCA/CP	ARA1	ARA2	ARA3
FCA 9 – CP2018-19			3/1/2018
FCA 10 – CP2019-20		8/1/2018	3/2/2019
FCA 11 – CP2020-21	6/1/2018	8/2/2019	3/3/2020

Source: ISO-NE

Starting in FCA 9 (2018-2019 capacity commitment period), ARAs clear supply against the same sloped demand curve that was used to procure capacity in the associated FCA. In contrast to earlier ARAs in which supply resources could shed obligations only if there were available unobligated capacity to take on those obligations, supply offers and demand bids

[4] Dominion purchased Millstone for $1.3 billion of which $105 million was for nuclear fuel. Even if capacity market prices cleared at around $5 / kW-month, the low end of recent clearing prices, the cost to Dominion to shed its obligations for any annual period would exceed $100 million.

clear against the demand curve and result in adjustments to participants' obligations; no matching supply offer is required.[5]

Recent experience in the ARAs indicates a level of demand bids that exceeds supply offers by a significant amount. The mismatch can be even more acute in the Connecticut Zone where Millstone is located. Dominion's additional 2,100 MW in demand bids would overwhelm the market if the market rules did not allow for ISO-NE to clear the market at a price set by the associated FCA demand curve.

Under the new structure that applies to ARAs associated with Commitment Period (CP) 2018-2019 and future commitment periods, a supply resource seeking to shed a CSO will be able to offset those obligations at a price determined by the intersection of the ISO-NE demand curve for the associated FCA with the supply curve.[6] ISO-NE may not reject a demand bid simply because the acceptance of that bid could procure less capacity than the Installed Capacity Requirement.[7] However, ISO-NE may reject a demand bid because it prevents "applicable reliability needs" from being met.[8]

As a result, assuming no finding of a reliability requirement, Millstone effectively has a pathway, in the form of the ARAs, to shed its large block of capacity. This pathway to exit is crucial for Dominion given the historical shortfall of supply offers to demand bids, especially for the Connecticut Zone (Figure 2).[9] However, Dominion will have to pay a high enough price to shed 2,100 MW of obligations, at the price set in accordance with the Market Rules.

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[5] Market Rule 1, Section III.13.4.8., "Adjustment to Capacity Supply Obligations."

[6] Market Rule 1, Section III.13.4.2.2.(c) Demand Bids in Reconfiguration Auctions. ". . . provided that for annual reconfiguration auctions associated with a Capacity Commitment Period that begins on or after June 1, 2018, the ISO shall not reject a demand bid solely on the basis that acceptance of the demand bid may result in the procurement of less capacity than the Installed Capacity Requirement (net of HQICCs)."

[7] ISO-NE, https://www.iso-ne.com/static-assets/documents/regulatory/tariff/sect_3/mr1_sec_13_14.pdf

[8] Market Rule 1, Section III.13.4.2.2.(c). Demand Bids in Reconfiguration Auctions.

[9] Market Rule 1, Section III.13.4. Reconfiguration Auction. "Supply offers and demand bids will be modeled in the Capacity Zone where the associated resources are electrically interconnected."

Figure 2: Recent ARA Bids and Offers for the Relevant Capacity Commitment Period

Capacity Zone Name	CP 2018-19 ARA1	CP 2018-19 ARA2	CP 2019-2020 ARA3
String	Demand Bids	Demand Bids	Demand Bids
MW	MW	MW	MW
Rest-of-Pool	1,288	1,125	1,335
Connecticut	561	0	
NEMA/Boston	24	12	
SEMA-RI	284	145	657
Maine			
External Interfaces	508	496	402
TOTAL	**2,666**	**1,778**	**2,394**
Capacity Zone Name	**CP 2018-19 ARA1**	**CP 2018-19 ARA2**	**CP 2019-2020 ARA3**
String	**Supply Offers**	**Supply Offers**	**Supply Offers**
MW	**MW**	**MW**	**MW**
Rest-of-Pool	226	132	257
Connecticut	64	104	
NEMA/Boston	14	78	
SEMA-RI	56	126	127
Maine			
External Interfaces	561	461	456
TOTAL	**922**	**901**	**840**
Excess Demand Bids versus Supply Offers	**(1,744)**	**(877)**	**(1,554)**

Source: ISO-NE, ISO New England Forward Capacity Market Reconfiguration Auction Results Summary

Given this market design that would allow for Dominion to buy out of its CSO, and the recent shortfall in supply offers compared to demand bids, the methodology to estimate the cost to Dominion to shed its CSO and therefore enable early retirement of Millstone, is relatively straightforward and includes the following steps:

1) **Capacity Payments:** Calculate the capacity payment owed to Millstone under the CSO using actual clearing prices ($/kW-month) and Millstone's CSO (MW).

2) **ARA Buy-out Price:** Estimate the ARA clearing price by removing Millstone's CSO (MW) from supply cleared in the original FCA and comparing that adjusted supply amount to the FCA demand curve; the ARA clearing price would be where the FCA demand curve meets the new net supply amount.

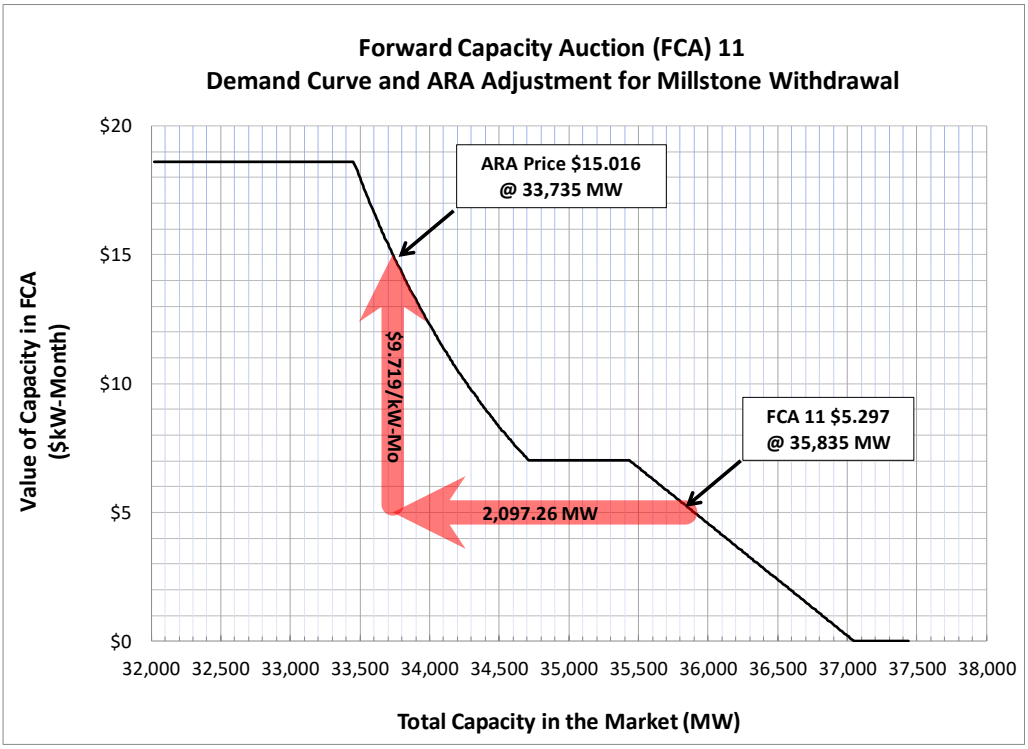
3) **ARA Cost:** Multiply the estimated ARA clearing price by the capacity Millstone is shedding to calculate the total cost of buying out of the CSO.

4) **Net Buy-out Cost:** Subtract Millstone's capacity payments under the FCA from the ARA buy-out cost to obtain the net incremental cost to Millstone to shed its CSO.

The following graph illustrates the general approach using a graphical illustration of supply and demand for CP 2020-2021 where the demand curve is set by the one used in FCA11. As illustrated in Figure 3, the 35,835 MW of capacity cleared in FCA11 would be reduced by approximately 2,100 MW with the Millstone withdrawal, holding all else equal. Millstone's withdrawal would increase prices along the ISO-NE demand curve from the FCA clearing price of $5.297 /kW-month to around $15 / kW-month. The $9.72 / kW-month difference times the CSO to be bought out (i.e., 2,097.26 MW) times 12 months reflects the net buy-out cost required to shed the Millstone CSO for FCA11. In other words, Dominion would have to spend around $245 million for the capacity commitment period June 2020 - May 2021 in order to retire both Millstone units before that obligation begins.[10]

[10] This calculation assumes that Millstone's withdrawal is incremental to other supply and demand bids. It is possible that the buy-out price could be higher or lower depending on the net supply obligation associated with other supply offers and demand bids submitted into the ARA.

Figure 3: Illustration of Millstone's Net Buy-out Charge for FCA11



Applying the same methodology to the FCA9 and FCA10 periods, the estimated cost for those periods would be $206 million and $230 million, respectively.[11]

A cross-check on the reasonableness of these results can be obtained using ARA bid and offer information published by ISO-NE. For CP 2017-2018, demand bids exceeded supply offers in each ARA. The maximum price of supply offers is close to the price that would be set using the ISO-NE demand curve. Even if the market could clear at the maximum price of previously uncleared supply bids, prices would settle at a level consistent with the estimates based on the demand curves of around $15 - $17 / kW-month (Figure 4).

[11] FCA9 and FCA10 capacity supply obligations have been modified slightly according to the subsequent ARAs. In the case of FCA9, Millstone's withdrawal would still place the ARA3 clearing price at the cap of $17.728 / kW-month, resulting in no change to the analytical results. In the case of FCA10, the net change in obligations during ARA2 was negative, making the methodological approach that starts with FCA10 a conservative estimate of the final clearing price that Millstone would have to pay of $16.163 / kW-month.

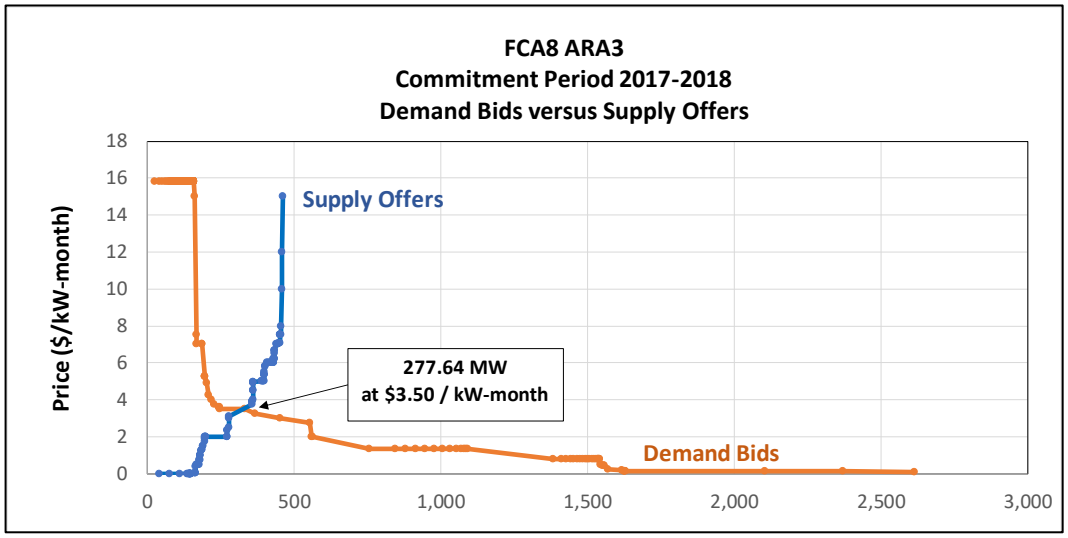
Figure 4: Recent ARA Demand Bids and Supply Offers for CP 2017-2018

CP	ARA	Demand Bids (MW)	Supply Offers (MW)	Cleared Capacity (MW)	Highest Demand Bid Price ($/kW-month)	Highest Supply Offer Price ($/kW-month)
2017-18	**ARA1**	1,111	318	316	$15.01	$17.00
2017-18	**ARA2**	2,831	567	243	$15.82	$15.75
2017-18	**ARA3**	2,616	461	278	$15.82	$15.00

Source: ISO-NE, Forward Capacity Market Annual Reconfiguration Auction Historical Bid Reports

The overwhelming impact that Millstone's potential withdrawal of 2,100 MW, which would be submitted as demand bids, is further illustrated by ARA3 for Commitment Period 2017-2018. In that ARA, only 277 MW cleared at a clearing price of $3.50 / kW-month. If Millstone had submitted 2,100 MW of demand bids in that auction, there would have been insufficient supply to meet Millstone's demand and the market clearing price would have had to exceed the highest supply offer of $15 / kW-month to clear (Figure 5).

Figure 5: Commitment Period 2017-2018 Supply and Demand Curves in ARA3



Source: Energyzt Analysis of ISO-NE data hbfcmara_ARA3_2017.csv

Millstone's withdrawal of 2,100 MW would have a significant impact on the market clearing price for ARAs. Under the new rules, ISO-NE will clear the market at the price set by the ISO-NE demand curve, generating prices above $15 / kW-month. Therefore, ISO-NE's demand curve and the methodology that uses that demand curve to set an associated ARA price with a Millstone withdrawal as described above serves as a reasonable estimate of the

price that Millstone would have to pay to shed its capacity obligations for the next three commitment periods.

3. Assumptions

Although most of the data required to follow the methodology described above is publicly available, the following assumptions are required to perform the analysis:

1) **Bilateral Markets would be Inadequate:** There would be insufficient incremental unobligated capacity available in the market that could take on the obligations from the Millstone capacity withdrawal. Historical levels of bilateral transactions, as well as the limited timeframe for new entrants to assume a CSO, support this assumption.

2) **ARA Prices Will be Set by the ISO-NE Demand Curve:** Changes to the supply or demand curve for the relevant FCA either do not occur or only occur at the extreme ends of the curves so that Millstone's withdrawal is priced at the original ISO-NE demand curve.[12]

3) **CSO Shedding in ARAs:** Millstone would immediately begin participating in ISO-NE ARAs to shed its CSO for FCA 9, FCA 10 and FCA 11 (i.e., 2018 – 2021), withdrawing the entirety of its capacity in a single ARA for each FCA capacity commitment period in order to be cleared of all obligations by mid-2018.

4) **Reliability Review:** ISO-NE's reliability review would not result in a finding that the Millstone units are needed for reliability, thereby allowing Millstone to buy out of its CSOs.

As discussed above, these assumptions are reasonable given historical bids and offers as well as the new market rules for ARAs.

[12] Relaxing this assumption could increase or decrease Millstone's cost to exit, depending on the relative amounts of bids and offers. As shown with previous bids in the CP 2017-18 ARA, however, there tends to be a lower quantity of supply offers compared to demand bids.

4. Estimate of Millstone's CSO Buy-out Cost

Millstone would be able to buy out of its CSOs through the ARAs by submitting a demand bid at the maximum allowable capacity price for the entirety of its CSO (i.e., around 2,100 MW). The system demand curve used in the ARAs starting in FCA 9 allows for an estimate of what the market clearing price would be, holding all else equal except for the Millstone capacity withdrawal from the market.

Using the methodology and assumptions described in the prior sections, Millstone's incremental cost to buy out of its capacity supply obligations through May 2021 would be around $680 million (Figure 6).

Figure 6: Estimate of Millstone's Net Buy-out Cost

Commitment Period	FCA Payments ($Millions)	ARA Buy-out Charge ($Millions)	Net Buy-out Cost ($Million)
FCA 9: CP 2018-19	241	-447	-206
FCA10: CP 2019-20	177	-407	-230
FCA11: CP 2020-21	133	-378	-245
TOTAL	**551**	**-1,232**	**-681**

Source: Energyzt calculation

This methodology assumes that Millstone bids the entirety of its CSO into a single ARA. This would be the case if Millstone intends to shed its capacity obligation by mid-2018.

ISO-NE's acceptance of Millstone's bids in the ARA would be subject to a reliability review.[13] Given ISO-NE's emphasis on risks associated with increasing reliance on natural gas, and historical support for a new natural gas pipeline to increase supply, ISO-NE may find that Millstone is required for reliability reasons in the near-term, or at least until more diversification in fuel source to New England is obtained If Millstone is found to be required for reliability reasons, ISO-NE would reject the ARA demand bids in their entirety and Millstone would be subject to its existing CSOs at the original FCA prices.

[13] A financial review ensuring Dominion's ability to guarantee payments also would be required. For purposes of this analysis, we assume the financial review would conclude with an ability to pay.

Even if ISO-NE did find that Millstone was needed for reliability reasons through 2022, however, it cannot, under its tariff, prevent Dominion from shutting down Millstone. Therefore, Dominion faces an economic decision tied to the costs of shedding its obligations and incurring other costs to retire, which could exceed $1 billion, versus projected profitability associated with maintaining operations either with or without a finding that Millstone is required for reliability reasons.[14]

5. Conclusion

Dominion may choose to attempt to buy out of its existing FCM capacity obligations, which would be subject to an ISO-NE financial and reliability review. In the absence of a reliability finding, Dominion could retire Millstone through the payment of the clearing price in the applicable ARAs. Such an approach would be costly.

Simply removing shifting up the demand curve by the amount of Millstone capacity withdrawal results in an incremental buy-out charge that would exceed the FCA payments Millstone currently is set to receive. The resulting cost to Dominion is estimated to be between $200 million and $250 million per capacity commitment period, for a total cost of approximately $680 million for Millstone to extinguish its existing capacity obligations, which would be required in order for the units to retire prior to the scheduled end of its obligations through 2021.

In addition, given Millstone's failure to submit a notification to withdraw its capacity from the upcoming auction for the 2021-2022 period, Dominion would incur additional costs to buy out of its obligation for that year. Including a buy-out of the current commitment to bid in FCA12, total costs to shed its capacity obligations to ISO-NE could approach $1 billion, not including a number of other costs Dominion would incur to retire Millstone outside of its ISO-NE market commitments, which could be substantial, but are outside the scope of this analysis.

[14] Such an economic analysis is outside the scope of this analysis. However, the prior Energyzt report found that Millstone was projected to be profitable as a result of high capacity prices through 2020 based on futures prices and guaranteed capacity payments, and profitable from 2021 forward based on price projections developed on behalf of ISO-NE as part of the Net-CONE proceedings.

DOCUMENTS AND DATA

ISO-NE, Market Rule 1, Section III.13.4

Letter from ISO-NE to Thomas P. Wohlfarth, Senior Vice President – Regulatory Affairs, Dominion Resources, Inc., June 23, 2017, http://www.ctnewsjunkie.com/upload/2017/06/ISOResponse_to_Dominion_Letter.pdf

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ISO-NE, "Reconfiguration Auctions," https://www.iso-ne.com/markets-operations/markets/forward-capacity-market/fcm-participation-guide/reconfigurations-auctions

ISO New England Manual for the Forward Capacity Market (FCM) Manual M-20, Revision: 24 Effective Date: February 3, 2017, Prepared by ISO New England Inc., https://www.iso-ne.com/static-assets/documents/2017/02/m20_forward-capacity-market_rev24_20170203.pdf

ARA Results

ISO New England Forward Capacity Market Reconfiguration Auction Results Summary

fcmara_CP-2017-18_ARA3.csv
fcmara_CP-2018-19_ARA1.csv
fcmara_CP-2018-19_ARA2.csv
fcmara_CP-2019-20_ARA1.csv

ARA Bids and Offers

Forward Capacity Market Annual Reconfiguration Auction Historical Bid Report

hbfcmara_ARA1_2017.csv
hbfcmara_ARA2_2017.csv
hbfcmara_ARA3_2017.csv

FCA #9

Auction Results:
https://www.iso-ne.com/static-assets/documents/2015/02/fca_9_cso_flow_diagram.pdf

Demand Curve Data:
https://www.iso-ne.com/static-assets/documents/2017/09/A2_2018ara3_2019ara2_2020ara1_icr_final_values_09252017.pdf

Millstone Commitment Data:
Document "2018-2019 CCP Forward Capacity Auction Obligations"
https://www.iso-ne.com/isoexpress/web/reports/auctions/-/tree/fca-results

FCA #10
Auction Results:
https://www.iso-ne.com/static-assets/documents/2016/02/fca_10_cso_flow_diagram.pdf

Demand Curve Data:
https://www.iso-ne.com/static-assets/documents/2017/09/A2_2018ara3_2019ara2_2020ara1_icr_final_values_09252017.pdf

Millstone Commitment Data:
Document "2019-2020 CCP Forward Capacity Auction Obligations"
https://www.iso-ne.com/isoexpress/web/reports/auctions/-/tree/fca-results

FCA #11
Auction Results:
https://www.iso-ne.com/static-assets/documents/2017/03/ccp_2020_21_fca_11_cso_flow_diagram.pdf

Demand Curve Data:
https://www.google.com/search?q=MRI+Values+FCA+11&oq=MRI+&aqs=chrome.0.69i59j69i57j0j69i59j0l2.3776j0j7&sourceid=chrome&ie=UTF-8
https://www.iso-ne.com/static-assets/documents/2016/09/a2_fca11_demand_curves.pdf

Millstone Commitment Data
Document "2020-2021 CCP Forward Capacity Auction obligations"
https://www.iso-ne.com/isoexpress/web/reports/auctions/-/tree/fca-results