Negative Pricing Discussion Paper

Introduction

The Net Demand Variability (NDV) study concluded that increased instances of supply surplus and accordingly additional cycling of assets in the market would occur as additional variable resources are added (See WG 9). The working group (WG) analysis overall also indicated that sufficient flexibility is likely to develop as new gas replaces retired coal (in the LTO reference case) or as coal converts to gas (CTG scenario). Further, analysis on the self-commitment model indicates that assets will position themselves based on a week forward view of the market. The purpose of this paper is to explore the option of introducing negative pricing as part of these design considerations (See WG 10).

The AESO currently employs an administrative mechanism to address supply surplus. Upon reaching $0/MWh in the energy market merit order, the AESO first curtails import assets, then $0 flexible blocks, including renewables, then $0 non-flexible blocks, and finally curtailing generation offline. This procedure has been very effective historically. The question is whether the existing protocol may be stressed in clearing supply surplus conditions including:

- **Imports**: The first step of curtailing imports can be difficult to manage as other variables such as system load continue to change; system variability may result in instances in which the system controller is often trying to curtail just the right amount of import to avoid dispatching back into priced energy and avoid dispatching down $0 blocks
- **Dispatch Variances**: When there are significant numbers of assets priced at $0/MWh, pro-rata dispatching of flexible blocks can result in instances of dispatches being sent to dozens of assets for small volumes. If the clearing solution only requires each asset to reduce generation to a range that is within their existing dispatch's allowable dispatch variance, the assets are not inclined to reduce generation to the new dispatch level needed to clear the supply surplus
- **Inflexible Blocks**: There is currently no reason required for setting an inflexible block. This can result in scenarios where otherwise flexible MW are set as inflexible to ensure they only need to reduce output in later curtailment steps

In combination with the expected increase in supply surplus instances and the potential issues with clearing supply surplus, it is possible these issues may be mitigated by lowering the price floor as it promotes further depth to the merit order resulting in less concentrated offers at the price floor where these issues materialize.

Negative Pricing and Jurisdictional Review

Negative pricing is a market-based alternative to utilizing an administrative mechanism to clear supply surplus based on economic offers by lowering the offer price floor below $0/MWh, thereby enabling market participants to signal their willingness to incur a cost to avoid curtailment from supply surplus rather than through involuntary curtailment. Therefore, once pool price within a market falls below zero as supply required to balance demand on the system reaches negative offer prices, power producers are paying load resources to take produced electricity.

Looking at the experiences of other jurisdictions, negative pricing is widely considered an improved alternative to manage congestion and over-generation that improves market efficiency and liquidity.. Increasing intermittent generation in export-constrained areas within a number of jurisdictions introduced

a growing number of supply surplus events. In response, these markets developed market-based mechanisms using negative prices. The following table summarizes generator offer floors across ISOs in North America and Australia, all of which allow for negative offers:

Market	Offer Floor
CAISO[1]	-$150/MWh
ERCOT[2]	-$250/MWh
ISO-NE[3]	-$150/MWh
MISO[4]	-$500/MWh
NYISO[5]	-$1,000/MWh
PJM	No Floor
IESO[6] (Ontario)	-$2,000/MWh
AEMO[7] (Australia)	$-1,000/MWh

While these markets have implemented negative pricing for the benefits it provides, other considerations from the experiences of these markets include:

CAISO – Setting the Price Floor

CAISO's 2002 market redesign had set a -$30/MWh bid floor while FERC modified the floor to be a "soft" bid floor allowing a generator to justify an economic bid price below that value.[8] However, in the CAISO's filings in 2014, the original floor had not taken into consideration the magnitude and frequency of renewable over-generation, as well as the effect of renewable energy credits on a generator's opportunity cost. FERC determined that CAISO's proposal to lower the bid floor to -$150/MWh should allow CAISO to rely more on market-based curtailment in periods of over-generation.[9]

From CAISO's experience, it appears that a negative price floor may simply move the high level of equal price offers to a new floor thus moving the supply surplus issue to a new price. The price floor must be set low enough to promote additional depth in the merit order.

Production Tax Credit and Negative Prices in the United States

In the United States, the federal wind Product Tax Credit (PTC) is an inflation-adjusted per-kilowatt-hour (kWh) tax credit for electricity generated by qualified energy resources originally enacted in 1992, renewed and expanded numerous times. Since 2015, a phase-out of the PTC has been established, with a value reduction each year through 2019.[10]

However, with the existence of the PTC, there have also been concerns from varying parties that it distorts price signals in wholesale electricity markets by incenting subsidized wind producers to sell electricity at a loss, despite the flexible operational characteristics of wind turbines, and may conflict with the performance and operational needs of electric systems. Further concerns were also identified related to investment signals noting that negative pricing creates upward pressure on prices above the floor to recoup lost revenue during negative clearing hours. Depending on the number of hours in negative pricing, total plant revenues may be insufficient to cover annual costs.

PJM, in particular, noted in 2017 the concern and impact of negative offers in evaluating energy price formation reform:

> *PJM has observed negative energy market offers from wind generation enabled by the federal wind production tax credit (PTC). The negative offers, encouraged by this production subsidy, negatively impact all resources by distorting price signals and*

eroding revenue streams. The erosion of value for assets needed to maintain critical resources used to ensure reliability is of particular concern given the intermittency of renewable resources.[11]

The Department of Energy (DOE) furthered the sentiment to mitigate negative offers to the broadest extent possible in its policy recommendation in August 2017. The DOE noted that generator profitability could become a public policy concern if so much generation is financially challenged that the reliability or resilience of the bulk power system become threatened; having further noted more frequent negative pricing being observed in constrained hubs that feature a relatively large amount of variable renewable energy and/or nuclear generation including PJM, CAISO and ERCOT.[12]

Developments and debates on this matter continue in the USand parallels exist in Alberta, including provincial carbon offsets, federal production incentives, and Alberta's new Renewable Energy Program.

IESO

Recognizing the impact on offer behavior that may result from subsidies, the IESO has also experienced complications in the implementation of a negative price floor. Initially, the IESO did not have dispatchable wind, and as noted by the Ontario Energy Board in 2011, "*Ontario may experience extreme negative prices when the price should have been at or near $0/MWh, if wind had been dispatchable."* Specifically, they found that if wind had been dispatchable, negative prices in the winter of 2010 would have averaged approximately negative $2/MWh rather than negative $97/MWh.[13] Furthermore, from 2009 to 2014, there were almost 2,000 hours in which the Hourly Ontario Electricity Price was negative.[14] Addressing concerns over negative pricing, wind would later become dispatchable in 2013 and implementing offer floors for flexible nuclear capacity and transmission-connected wind and solar. These price floors were set in order to better ensure efficient dispatches during periods of local and/or global surplus baseload generation events. The reasoning for which was that a dispatch order for baseload generation will produce real-time outcomes that: better promote market efficiency and cost-effectiveness; and minimize environmental impacts.[15] In addition, the IESO noted that in order to achieve the operational outcome that is desired and to ensure that appropriate signals are produced, the floor price for variable generation must be more negative than that set for flexible nuclear generation.[16]

While these price floors were enacted to maintain a specific dispatch order, akin to an administrative curtailment order, the introduction of resource specific price floors may also act as a form of offer mitigation, effectively limiting these resources from pricing the lost opportunity cost of curtailment into their offers.

Based on these initial jurisdictional observations, the impact of subsidies distorting market outcomes and eroding revenue streams has yet to be resolved noting that while the reduced price floor addressed some issues, it may have created some other issues. It could that Alberta will face similar challenges intermittent generation becomes a greater proportion of the generation fleet.

Resource Impact Review:

This section summarizes how different resources may price with the introduction of negative pricing in Alberta and noting additional considerations that may warrant further discussion and evaluation. Each asset class will factor curtailment costs into negative offers, including their direct and indirect marginal costs (e.g. fuel, maintenance costs) from cycling, as well as opportunity cost (e.g. forgone profit incurred from down time, from both the energy market and other revenue sources):

Resource	Pricing in Supply Surplus Conditions	Considerations

Category		
Renewables	Wind and solar are expected to have lower operational and maintenance costs relative to traditional generation, and can vary depending on the size, age, and location of the wind plant. However, curtailment costs also stem from other revenue sources that are forgone in curtailment leading to negative offers.	Alberta's wind generators would lose revenue from provincial carbon offsets and federal production incentives, subject to similar concerns as the PTC in the US.
Renewables (Indexed REC)	An Indexed REC mechanism incents these participants to price their capability at the price floor to minimize the risk of curtailment.	Raises questions as to whether these unmitigated offers erode value for higher marginal cost inflexible assets that would otherwise be economically dispatched off first.
Coal and Gas Conversion	Increased cyclying will mean that large plants may face significant curtailment costs and lost opportunity costs incurred by not generating during the entire minimum down time following shutdown, even after prices have risen to profitable levels. These costs should be significantly greater than the curtailment costs of imports, renewables, and to varying degrees, gas.	Coal to gas conversion should lead to increased flexibility with units expected to have smaller must-run blocks.
Cogeneration	Typically generate at near-constant levels during surplus events, and will generally have very high curtailment costs, as oilsands and other industrial processes tend to critically depend on the steam output. The cost of curtailing cogeneration would vary across industries, and could be estimated based on the opportunity costs of production and potential equipment damage costs of shutdowns.	Cogeneration makes up a significant portion of the Alberta generation fleet in contrast to other jurisdictions that may warrant further evaluation
Hydro	While some hydroelectric resources in Alberta are able to spill water, they currently do so only in emergencies, and operational restrictions may prevent other resources from spilling at all. It is noted that some large units with reservoir storage may be able to reduce output when prices fall to $0/MWh, but do not curtail production entirely. Management of Hydro resource capability, including the impact of supply surplus on hydro resources is highly dependent on seasonality.	Hydro is subject to environmental regulations that may prevent curtailment due to inability to spill water. This raises questions as to the extent resources subject to other legislative requirements preventing curtailment may be negatively impacted by negative prices.
Simple Cycle Gas	Typically peaking units and offline prior to approaching supply surplus conditions	
Combined Cycle Gas	Run at minimum generation levels to avoid shutdown. Primarily cycling costs and the opportunity costs of not generating following a shutdown. However, because combined-cycle plants tend to be more flexible than coal units, their opportunity costs are expected to be significantly lower and consequently be economically curtailed before coal plants.	Curtailment costs may be dependent on gas generation facilities' fuel arrangements but would not be expected to change asset behavior.
Import (Priced & Dispatchable)	Currently scheduled as price takers and not dispatchable based on economic offers, and import curtailment is the first step taken in supply surplus. Dependent on the outcome of priced interchange, there may be the introduction of offer-based dispatch of imports. In such a case, the opportunity	In priced import environment, raises question as to whether there is any reason imports should remain curtailed first when approaching supply surplus – tradeoff between opportunity

	costs and associated curtailment offers of imports would be based on transmission charges and the opportunity cost of selling power in other markets.	tariff and capacity obligations.
Import (Non-dispatchable)	If imports can remain price takers, they may otherwise be exposed to negative pricing.	Raises questions as to whether non-dispatchable resources should be exposed to negative prices or to initiate curtailments of these non-dispatchable resources at $0/MWh.
Dispatchable Load	Currently no dispatchable load participates, but demand resource participation is being introduced in the capacity market. A negative bid equates to a willingness to increase load at that price.	
Load (Export)	Exports, also subject to priced interchange decisions, would have opportunity costs and associated curtailment offers based on transmission charges and the opportunity cost of buying power in other markets.	Currently allowed to submit bids to export within T-2 in supply surplus conditions. Raises question as to whether both non-dispatchable or dispatchable exports will still be given the opportunity for T-2 bids in negative pricing.
Energy Storage facilities	Currently there are no energy storage resources, but would be in a good position to take advantage of negative pricing. During times of supply surplus, these assets can earn revenues from consuming and storing electrical energy.	

Rule Changes:

To implement a negative price floor, the following ISO rules have currently been identified as requiring amendments:

- Section 103.4 Power Pool Financial Settlement
- Section 201.5 Block Allocation
- Section 201.6 Pricing
- Section 202.3 Issuing Dispatches for Equal Prices
- Section 202.5 Supply Surplus
- Section 203.1 Offers and Bids for Energy
- Section 203.3 Energy Restatements

Further Considerations:

- **Setting the Price Floor**: A negative price floor may simply move the high level of equal price offers to a new floor thus moving the supply surplus issue to a new price. The price floor must be set low enough to promote additional depth in the merit order.
- **Products Indexed to Pool Price:** Active operating reserves are indexed to pool price and currently cannot go below $0/MWh. However, the real power provided for a product (e.g. regulating reserve) during negative pricing would incur a cost to the provider. Requires consideration on whether they are isolated from the effect (e.g. if providers do not pay, what covers the difference, or if the risk is theirs to bear, does it have reliability and liquidity risks)
- **System Changes:** Scope of changes to market systems including Energy Trading System (ETS) and Dispatch Tool,(DT) and settlement processes need to be assessed
- **Impact on TCM:** Transmission constraint management may require adjustments to accommodate negative pricing

Key Findings:

The experiences of other jurisdictions indicate that these markets developed market-based mechanisms using negative prices in response to increases in intermittent generation. This rule should be studied as additional variable resources are added and if issues to clearing the supply surplus occur. ,. While consideration of a negative price floor is warranted, at this point this rule change is not a priority. Further administrative rules can be considered to clear the surplus efficiently as an early alternative to introducing negative pricing.

The stresses that the existing administrative mechanism may encounter in efficiently clearing supply surplus conditions can also be addressed by other means without the need for negative pricing, including these options:

- **Imports**: Allow intertie assets the option to submit offers in price quantity pairs upon request of a new asset, in which case they will be dispatched during the settlement period, and may set SMP. This will separate the distinction of how to handle imports and can mitigate the challenges encountered by system controllers in balancing the system, including in the first step of supply surplus.
- **Dispatch Variances**: Pro-rata dispatching of $0 blocks in supply surplus that result in assets not reducing output due to allowable dispatch tolerances may alternatively be mitigated by removing the upper tolerance for supply surplus dispatches. Variances would only apply at or below the dispatch level in these conditions.
- **Inflexible Blocks**: Require inflexible blocks to be limited to operational reasons

If and when negative pricing is further evaluated for implementation in the Alberta market, several considerations should be taken into account. Some jurisdictions have also experienced complications: ensuring the price floor is set low enough, concerns over the effects of subsidies on market outcomes, and the need to implement resource specific price floors. Furthermore, the treatment of intertie assets, operating reserve providers, and resources subject to other legislative requirements, as well as the full scope of system and rule changes required, need to be evaluated in further depth.

[1] CAISO FERC Electric Tariff - v. July 10, 2017
[2] ERCOT - Current Protocols - Nodal
[3] ISO New England - Tariff
[4] MISO - Tariff
[5] NYISO - Tariff
[6] IESO - Market Rules & Manuals Library
[7] Australian Energy Market Commission (AEMC) - National Electricity Rules
[8] CAISO - Renewable Integration: Market and Product Review - September 30, 2010
[9] FERC - Docket No. ER13-2452-0000 - December 19, 2013
[10] ENERGY.GOV - Renewable Electricity Production Tax Credit (PTC)
[11] PJM - Energy Price Formation and Valuing Flexibility - June 15, 2017
[12] Department of Energy Staff Report to the Secretary on Electricity Markets and Reliability - August 2017
[13] Ontario Energy Board - Monitoring Report on the IESO-Administered Electricity Markets - November 2011
[14] 2015 Annual Report of the Office of the Auditor General of Ontario – Page 216
[15] IESO - Market Rule Amendment Proposal - MR-00381-R03 - 2012
[16] IESO - Renewable Integration Completed Engagement (SE-91)