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November 27th, 2018

Daniel P. Wolf
Executive Secretary
Minnesota Public Utilities Commission
121 7th Place East, Suite 350
Saint Paul, MN 55101

RE: Comments on Xcel Energy's 2019 VOS Calculation and Proposed 2019 Vintage Year Bill Credit Tariff Sheets (Docket No. M-13-867)

Dear Mr. Wolf,

Assistant Professor Gabriel Chan, Center for Science, Technology, and Environmental Policy and the Humphrey School of Public Affairs, University of Minnesota, hereby provides comments regarding PUC Docket No. M-13-867, which involve Xcel Energy's 2019 Value of Solar (VOS) calculation and proposed 2019 vintage year bill credit tariff sheets. These comments are in reference to the notice published on October 29, 2018. Matthew Grimley and Nick Stumo-Langer, Graduate Research Assistants of the Center for Science, Technology, and Environmental Policy, University of Minnesota, join as co-signers of these comments.

1. Background

In these comments we raise a number of points organized by degree of complexity, from (a) a conceptual error, (b) conceptual extensions, and (c) process reform. We perform a set of calculations based on transparent assumptions to illustrate the impact of our points on the levelized VOS.

In summary of the following analysis:

a) Correcting a conceptual error in the spreadsheet's formula for calculating inflation-adjusted environmental benefits of CO_2 emissions reductions would raise the levelized VOS to **$0.1068 per kWh** from Xcel Energy's August 1, 2108 filing of $0.1046 per kWh.

b) Conceptual extensions to more accurately capture marginal emission factors in Northern MISO would raise the levelized VOS to **$0.1142 per kWh**; and replacing natural gas price futures with natural gas price forecasts would raise the levelized VOS to **$0.1372 per kWh**. Table 1 summarizes these cumulative revisions.

c) We conclude with comments on reforming the procedural setup of revising VOS tariffs to strengthen the role of oversight so that future revisions to the VOS balance the multiple roles played by the VOS in furthering the public interest.

The importance of a properly estimated value of solar has been broadly recognized. In Xcel Energy's comments to the PUC regarding the VOS methodology in Docket No. E999/M-14-65, the company states, "when the amount customers are paying for distributed solar equals the costs that are avoided, there is no impact on rates and no inequity between solar and non-solar customers." We agree with the notion that an accurate VOS makes Minnesota's energy system more fair. We also note that because of its role as a tariff, the VOS also plays a critical role in setting the incentive for solar garden development and should also be considered a key market-shaping incentive in addition to its role in providing fairness in solar development. In this second of two dual functions, recognition that the VOS plays a key role in shaping the community solar market implies that it must be set clearly and in a way that fairly sets market expectations.

Table 1. Summary of Analysis, Expressed in Levelized VOS

Description of Change	Progressive Revisions to Levelized VOS ($/kWh)	Percent Change Relative to Original Calculation
Original Xcel Energy calculation in 2019 VOS filing	0.1046	-
2.1. Correction to inflation adjustment of Social Cost of Carbon	0.1068	+2.1%
+ 2.2. Replacement of marginal emission factors used in calculating environmental benefits to reflect marginal sources in Northern MISO (from Li, et al. 2017)	0.1142	+9.1%
+ 3. Replacement of natural gas futures prices with forecasted natural gas prices from EIA AEO 2018	0.1372	+31.2%

2. Calculation of Avoided Environmental Costs of CO_2 Emissions

2.1. Correction to Inflation Adjustment of Social Cost of Carbon

The VOS methodology specifies the procedure for calculating the avoided environmental costs of CO_2 emissions. The procedure involves updating the schedule of estimated benefits of CO_2 emissions reductions from the federal Interagency Working Group (IWG) on the Social Cost of Carbon (SCC) in Executive Order 12866. The IWG estimates the SCC in real 2007 dollars on an annual basis and Xcel's approach has been to adopt SCC estimates for every 5 years and interpolate the interim years. The VOS methodology (p. 40) calls for taking these values and then "adjust[ing] for inflation … convert[ing] to dollars per short ton, and then convert[ing] to cost per unit fuel consumption."

We believe we have discovered an error in the implementation of how Xcel Energy's VOS filing Attachment L implements the calculation of environmental externalities. In the attachment, column E inflates the SCC figures from real 2007$ figures to real 2015$ figures using the Consumer Price Index. Then, Column F, rows 14-49 are meant to calculate the nominal SCC for each year 2015-2050 by adjusting the real values in 2015$ in column E. However, the formula in

Column F treats the values in Column E as if they were reported in 2018$ by making a static reference to cell H3. Instead, this reference should be to the constant 2015, so that values are properly inflated relative to the year in which they are expressed. A rule of thumb is that real and nominal prices should be equivalent when examining prices in the year in which real values are expressed (i.e. the nominal and real SCC should be equivalent in 2015 because the real SCC values in column E are expressed in 2015$).

Implementing this correction and transposing the values into Table 4, column D, rows 6-30, results in a levelized VOS of $0.1068 per kWh, a 2.1% increase relative to Xcel Energy's filing.

2.2. Approximation of Marginal Emission Factors

We believe that there is sufficient evidence to suggest that the North region of MISO, which includes all of Minnesota (as well Iowa, Montana, North Dakota, South Dakota, and Manitoba), has a marginal fuel profile that diverges significantly from the VOS methodology's assumption of 100% natural gas displacement.

In calculating avoided environmental costs, the VOS methodology (p. 5) states:

> *This methodology assumes that PV displaces natural gas during PV operating hours. This is consistent with current and projected MISO market experience. During some hours of the year, other fuels (such as coal) may be the fuel on the margin. In these cases, natural gas displacement is a simplifying assumption that is not expected to materially impact the calculated VOS tariff. However, if future analysis indicates that the assumption is not warranted, then the methodology may be modified accordingly. For example, by changing the methodology to include displacement of coal production, avoided fuel costs may decrease and avoided environmental costs may increase.*

The environmental benefits of solar generation accrue on the margin of generation, not the margin of capacity. Therefore, the environmental avoided costs should be based on the generation in MISO that is not dispatched due to solar generation. This consideration is distinct from other avoided costs in the VOS methodology that assume that natural gas is the marginal new form of capacity.

In particular, we would like to highlight a peer-reviewed study from 2017 by Li, et al., "Marginal Emission Factors Considering Renewables: A Case Study of the U.S. Midcontinent Independent System Operator (MISO) System," published in *Environmental Science & Technology*[1]. Li, et al. calculate marginal emission factors and marginal fuels in MISO and its subregions based on hourly and 5-minute real-time fuel data in MISO from 2014. The authors find that in North

[1] Li, et al., "Marginal Emission Factors Considering Renewables: A Case Study of the U.S. Midcontinent Independent System Operator (MISO) System," published in *Environmental Science & Technology* (51): 11215-11223 (doi: 10.1021/acs/est.7b00034).

MISO in 2014 the marginal fuel was natural gas only 3.8% of the year. Coal was the marginal fuel 66.8% and wind was the marginal fuel 28.9% of the year.

It is important to note that marginal emission factors are not static and are likely to evolve over the lifetime of a solar project receiving the VOS tariff. Further, marginal emissions vary by time of day, and so avoided environmental costs will also depend on hourly dispatch in North MISO (inside and outside of Xcel's system). Thus the avoided environmental costs over the lifetime of a solar project are inherently uncertain and must be estimated in a transparent and consistent manner.

Given changes within MISO over the past four years that have seen increasing natural gas and wind deployment, it is likely that marginal emission factors have declined relative to Li et al.'s estimate using 2014 data[2]. It is also plausible that marginal fuels in the daytime hours when solar is producing are different than the yearly average. However, Li et al.'s analysis also demonstrates that natural gas was rarely (3.8%) a marginal fuel in North MISO at any point in 2014. Therefore, an assumption of natural gas comprising 100% of the relevant marginal generation displaced by solar is very far from historical evidence.

To illustrate a first-order approximation of the marginal CO_2 emissions (that admittedly does not take into account changes since 2014 or differences between marginal generation in solar vs. non-solar hours), we display the 2014 annual-average estimates of marginal fuels for North MISO from Li et al. in comparison to the assumed emission factor in the VOS calculation in Table 2[3].

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[2] For example, MISO published the MISO 2017 Summer Assessment Report in October 2017, which found that over MISO as a whole, coal has been playing a decreasing role as a marginal fuel over the past three years but still was a marginal fuel in 75.8% of 5-minute intervals in the summer of 2017, as compared to 87.0% of 5-minute intervals in summer 2015. (see page 14: https://cdn.misoenergy.org/2017%20Summer%20Assessment%20Report103564.pdf)

[3] The marginal emission factors of other pollutants also vary with the actual fuel mix of marginal electricity sources. However, to illustrate the importance of taking into account the fuel mix of marginal emissions sources, we focus just on CO_2 emissions, which make up 89-93% of annual avoided environmental costs in the VOS methodology, as implemented. However, because coal has higher SO_2 and particulate matter emissions relative to natural gas, the resulting calculations are lower than they would be if these other pollutants were taken into account. We also focus on the lowest estimate of emission factors of different coal types for illustration.

Table 2. Marginal Fuels in VOS and Estimated for North MISO and CO_2 Emission Factors

	Marginal Fuel			Average Marginal Emission Factors for CO_2 (lb/MMBTU)
	Coal	Natural Gas	Wind	
Assumed in VOS Calculation	0%	100%	0%	117.0
Estimate of the relative frequency of marginal fuels for 2014 North MISO by Li et al. (2017)	66.8%	3.8%	28.9%	141.9 - 157.2 [a]
Fuel-Specific Emission Factors (lb/MMBTU)	205.7 - 228.6 [b]	117.0	0.0	

[a] This range represents the weighted average of emission factors by marginal fuel type. Emission factors for different coal types define the upper and lower ends of the range.
[b] This range represents the emission factors for different coal types, as reported by the EIA in 2016, available at: https://www.eia.gov/environment/emissions/co2_vol_mass.php.

Incorporating the marginal emission estimates implied by Li et al.'s analysis by replacing cell J10 in Attachment L with the estimate of 141.9 lbs CO_2/MMBTU would result in a levelized VOS of $0.1141 per kWh, a 9.1% increase relative to Xcel Energy's filing (combined with the inflation correction detailed above in Section 2.1).[4,5]

There is a further consideration in assuming less than 100% natural gas displacement in the VOS. The significant role that coal plays as a marginal fuel in North MISO also highlights a key point that the "solar weighted heat rate" should also take into account the heat rate of coal and not simply be a weighted average of CT and CCGT natural gas turbine heat rates, particularly for accounting of avoided environmental costs. EIA estimates[6] that coal heat rates were 34% higher than natural gas heat rates in 2017 and we calculate that coal heat rates in 2017 were 39.7% higher than the reported "solar weighted heat rate" in Xcel's 2019 VOS submission (Table 5). We note that avoided fuel costs and avoided environmental costs move linearly with the "solar

[4] Instead of the lower emission factor estimate of 141.9 lbs/MMBTU (which corresponds to Bituminous coal), if instead the higher estimate of 157.2 lbs/MMBTU (corresponding to Anthracite coal) is used, the levelized VOS would be $0.1187 per kWh, or 13.5% higher than the original Xcel submission.

[5] Li et al. (2017) also directly measures marginal emission factors for several pollutants, including CO_2. The study finds that North MISO had a marginal CO_2 emission factor of 0.67 tons/MWh in 2014. This can be converted to 392.7 lb/MMBTU, which is significantly higher than the estimates shown in Table 2. If this direct estimate of marginal emission factors is used instead, the levelized VOS would be $0.1882 per kWh. However, we are unsure if the direct measure of marginal emissions can be directly compared to the emission factors established in the VOS methodology and implemented in the spreadsheets. Our recommendation would be to revise the VOS methodology to accommodate these more direct measures of marginal emission factors and to calculate the marginal emission factors based on hourly solar generation potential.

[6] EIA heat rate estimates are available at https://www.eia.gov/electricity/annual/html/epa_08_01.html

weighted heat rate," implying that each percent increase in the "solar weighted heat rate" implies a proportional change in these two avoided cost components. There are also non-linear decreases in avoided generation capacity and avoided reserve capacity with increasing "solar weighted heat rate."

Overall though, to bound the analysis, replacing the reported "solar weighted heat rate" of 7,493 BTU/kWh with EIA's estimate of coal's heat rate of 10,465 BTU/kWh would result in a 15.3% increase in the levelized VOS, to a level of $0.1316 (taking into account the marginal emission factors and the inflation correction described above).

It is also important to reemphasize that the marginal emissions relevant for solar deployment depend on many factors, but the VOS methodology is clear that if "future analysis indicates that the assumption [of 100% natural gas displacement] is not warranted, then the methodology may be modified accordingly. Here we have argued that the 100% natural gas displacement assumption may indeed not be warranted, and we recommend that more detailed analysis of avoided environmental costs be conducted to take into account hourly variation and anticipated changes in estimated marginal emissions over the lifetime of a solar project. We note that using a "solar weighted heat rate" as a critical parameter in avoided environmental costs appears to be an unduly complex and potentially fraught approach to calculating the environmental benefits of solar production. The Minnesota Pollution Control Agency reports facility-level emissions of criteria pollutants[7]. Li et al. have also developed region-specific marginal emission factors based on data reported by MISO. Both of these approaches could also be used to develop more direct and transparent measures of avoided emissions that would avoid the unnecessary complexity of a counterfactual "solar weighted heat rate" which cannot be directly measured or assessed.

This consideration of marginal fuels also points to the need to revise avoided fuel costs in the VOS calculation. However doing so would imply considering not just avoided natural gas costs (discussed below), but also forecasts of avoided costs of coal and wind. We do not perform these calculations here but note that this would be an important offsetting factor to consider as the assumption of marginal fuels is reexamined.

3. Future Natural Gas Prices

Avoided costs of natural gas are a critical component of the VOS calculation. Importantly, the VOS methodology effectively passes through volatility in natural gas spot prices in setting the solar reimbursement rate, creating new risk for solar developers rather than incentivizing solar development for solar's avoided-fuel benefits and failing to reflect future forecasts of natural gas prices.

Xcel Energy has highlighted changing natural gas prices as a key explanation for why the VOS has been revised over time. For example, in its September 30, 2016 filing in regards to the 2017 vintage VOS, Xcel Energy stated, "this calculation represents a per kWh increase of 0.38 cents in 2017 … the increase is ***driven primarily by higher natural gas*** and environmental costs as well as the impact of a lower escalation rate." (emphasis added). One year later, on October 2, 2017,

[7] See https://www.pca.state.mn.us/air/permitted-facility-air-emissions-data

in its filing in relation to the 2018 vintage VOS, Xcel Energy stated, "this calculation represents a per kWh decrease of 0.27 cents in year 1 … the decrease in pricing is ***primarily driven by lower natural gas market costs***, and environment costs." (emphasis added).

In principle, natural gas prices are included as an avoided cost to represent the natural gas purchases in the overall system that are avoided over the full lifetime of a solar project. This inherently requires forecasting natural gas prices over multiple decades, which have historically been highly volatile. The VOS methodology offers three options for calculating natural gas price forecasts. In practice, Xcel Energy has used the option based on publicly traded natural gas NYMEX futures (based on the average price of traded futures over the past several months for an initial period and then extrapolated at a fixed rate based on historical inflation beyond that). This approach relies on the assumption that natural gas futures contracts, as traded over the last few months before the VOS submission, represent reasonable forecasts of what the purchase costs of natural gas will be in the future.

The NYMEX-centered approach is concerning for two reasons:

1) Natural gas futures more than a few years out have low trading volume; and
2) Natural gas prices futures do not only reflect expectations of future spot prices. We explain these two concerns below.

First, a critical concern of using natural gas futures contracts is that futures with long maturities have very low trading volume. The more buyers and sellers there are for a futures contract of a specific maturity, the more robust extrapolations from futures prices to market expectations of future spot prices -- with low trading volume, the price of futures contracts conveys very little information. For example, based on data collected on November 20, 2018 from CME Group, in 2023, the fifth year of the VOS calculation, there were only 21.6 active natural gas futures contracts expiring in each month of the year. This drops to 14.0 contracts per month in 2024; contrast this with over 94,0000 natural gas futures contracts expiring in 2019, over 10,400 expiring in 2020, and over 850 expiring in 2021. Figure 1 below shows the sharp dropoff in futures market liquidity after the third year of the current VOS.

In Xcel Energy's filing, Attachment H, which includes natural gas futures contract prices, the futures through December 2030 are included, but to our knowledge, there is virtually no trading of futures contracts this far out[8] (there have been not trades for natural gas futures from 2028 - 2030 in the five most recent days of trading from November 19 - 26, 2018). The extremely low trading volume after this period should raise concerns that futures prices are not reflective of market expectations of future price changes.

[8] We note that CME's website does not display price quotes for futures after November 2028, and that these prices may only be accessible with proprietary applications.

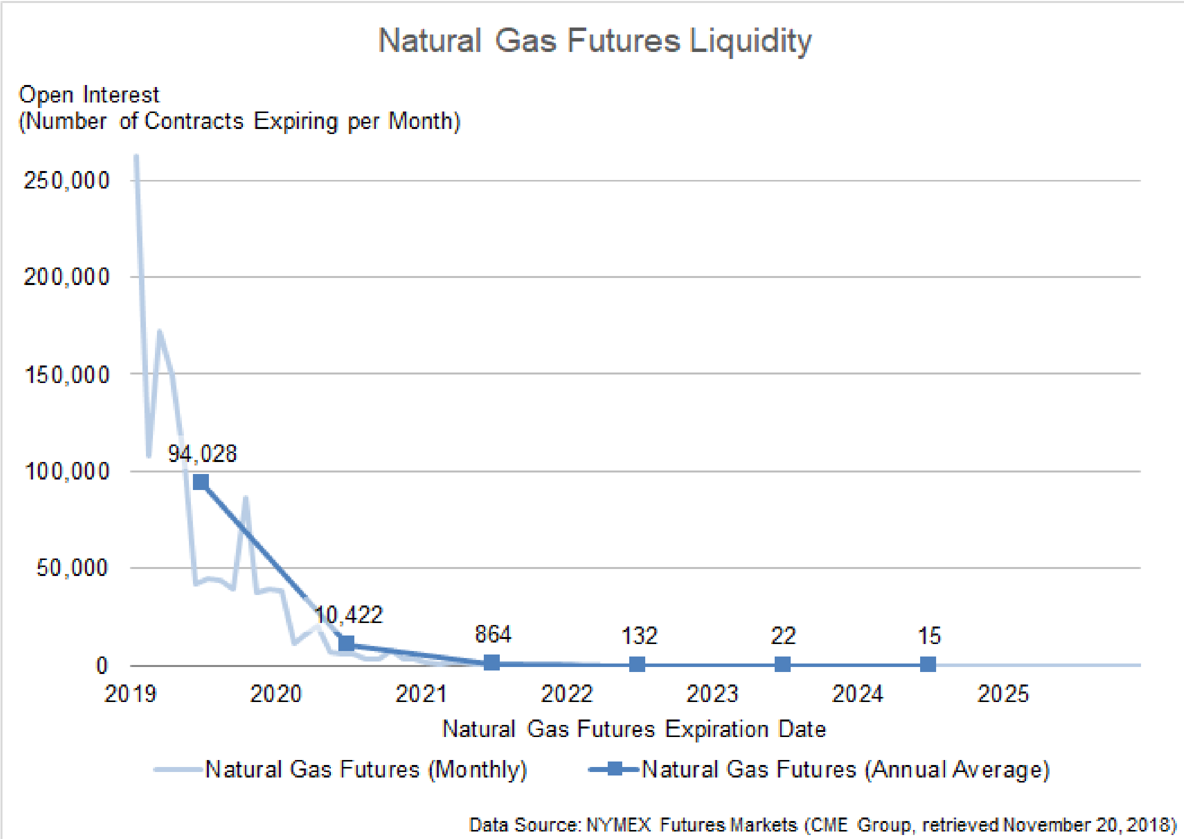

Figure 1. Liquidity in Natural Gas Futures Contracts by Month of Contract Expiration, as Measured by Open Interests (Retrieved November 20, 2018)

Second, there are reasonable concerns that natural gas futures prices may not be a good forecast for future avoided fuel costs. The Federal Reserve Bank of St. Louis provides a helpful explainer on the general conditions under which futures prices can provide a reasonable basis for price forecasts[9]. According to the Bank, a critical dimension for understanding the relationship between spot prices, futures prices, and actual prices in the future is the cost and feasibility of commodity storage. While futures prices for commodities that cannot be stored may indeed reflect expectations of future spot prices, critically, "for storable commodities with large inventory overhangs--say, several months' worth of consumption of the commodity--futures prices simply reflect the current spot price plus carrying costs." The rationale for this difference is that with significant storage capability, traders can purchase a commodity when prices are low, store the commodity until prices rise, and therefore arbitrage any differences between futures prices and spot prices.

Natural gas is storable in limited quantities. The EIA reports that there are 383 active natural gas storage facilities in the United States, including 1,226 bcf of storage in the Midwest, 26% of the natural gas storage in the lower 48 states[10]. In the 2017 Northern States Power-Minnesota 10-K

[9] Emmons, William and Timothy Yeager (2002). Federal Reserve Bank of St Louis. Available at: https://www.stlouisfed.org/publications/regional-economist/january-2002/the-futures-market-as-forecasting-tool-an-imperfect-crystal-ball

[10] See https://www.eia.gov/naturalgas/storagecapacity/

submission to the U.S. Securities and Exchange Commission[11], the company stated, "NSP-Minnesota purchases natural gas from independent suppliers, generally based on market indices that reflect current prices…In addition, NSP-Minnesota contracts with providers of underground natural gas storage services. These agreements provide storage for approximately 26 percent of winter natural gas requirements and 29 percent of peak day firm requirements of NSP-Minnesota." As natural gas has important but not unlimited storage capacity, the St Louis Fed's advice should be heeded, that "futures market prices for storable commodities with typically modest inventory overhangs must be interpreted with particular care" and should not be treated as "perfect crystal balls after all."

An alternative to utilizing futures prices as forecasts of natural gas prices (particularly long-run natural gas prices), is to incorporate insights from economic model forecasts.

For example, one of the most well-known energy-market forecasts is the U.S. Energy Information Administration's Annual Energy Outlook (AEO). The AEO provides yearly updates of many energy market forecasts based on the National Energy Modeling Systems (NEMS) model. These forecasts include projections of natural gas prices for over 30 years. While forecasts have many well-known flaws, they have the advantage of being robust to short-term speculation and idiosyncrasies. In a very similar context to setting the VOS, researchers at the Lawrence Berkeley National Lab (LBNL)[12] "recommend that analysts and policymakers select among 'blended' base-case gas price forecasts that utilize NYMEX futures price data when available and long-term fundamental price forecasts thereafter."

The California Energy Commission (CEC) provides a useful discussion of the use of natural gas price futures in its 2011 report, "2011 Natural Gas Market Assessment: Outlook in Support of the 2012 *Integrated Energy Policy Report Update*." The report states, "less than 1 percent of all natural gas futures contracts are ultimately held for physical delivery. The fact that so few futures contracts are tied to physical deliveries tells staff that many times these contracts may be used for other purposes such as price hedging....futures prices leave the forecaster (and the consumers of the forecast) in the dark, as the assumptions that were made (by the traders) are not knowable." Continuing, the CEC study states, "most futures transactions take place within the first few years of the tradable horizon for a given contract. There are few buyers and sellers trading futures contracts many years out into the future…If a long-term forecast is the goal, the futures market may not provide a large enough sample size of the market to accurately predict market interactions far into the future... In the short run, the futures price of natural gas may be an adequate forecast, but for terms spanning more than a few years, futures market natural gas prices may not be a good gas price forecast."

Citing the LBNL study also referenced above, the CEC explains its decision in 2005 to adopt the so-called "blended" forecast that combines short-term futures prices with forecasts from the Energy Information Administration's AEO (although this approach was not carried forward in future proceedings). The CEC report states, "the California Public Utilities Commission has used a blended natural gas price forecast to estimate an electricity MPR [marginal price referent] that,

[11] See page 16: http://www.snl.com/Cache/c392333702.html

[12] Bolinger and Wiser, 2010. Available at: https://emp.lbl.gov/sites/all/files/update-memo-lbnl-53587.pdf

in turn, has been used as long-term price benchmark for acquiring renewable energy generation to comply with the Renewable Portfolio Standards (RPS) obligations."

In a more recent report supporting California's 2013 Integrated Energy Policy Report[13], the CEC describes its shift to a fully model-based forecast of natural gas prices based on "the North American Market Gas Trade Model, based upon plausible and transparent assumptions, to give planners and decision makers information about the possible supply, demand, and price of natural gas in the future." This fully model-based forecasting approach continues to be used, as recently as the CEC's 2017 Natural Gas Market Trends and Outlook report to support the 2017 Integrated Energy Policy Report[14].

The Minnesota VOS calculation's context would seem to be very similar to that faced by the California Public Utility Commission in adopting a natural gas price forecast to inform how an incentive for renewables is set. We recommend that the Minnesota PUC consider revisions to the Value of Solar methodology to incorporate transparent alternatives to futures markets in setting this critical parameter in the VOS. While we do not necessarily recommend that the PUC adopt the AEO's forecast as a complete replacement for the use of futures market prices, here we illustrate an upper bound estimated by replacing the current methodology's approach based on futures prices with the AEO's price forecast (Figure 2).

Figure 2 below displays historic natural gas prices (annual averages as reported by the EIA), the current forecast values based on NYMEX futures in the 2019 vintage VOS calculation, the current NYMEX futures updated earlier this week, and natural gas price forecasts from the 2018 AEO in real terms (as reported in the AEO) and nominal terms (as inflated at the 2.25% used in the VOS calculator). The calculation above uses the nominal values to correspond with the calculator's assumptions.

[13] See https://www.energy.ca.gov/2014publications/CEC-200-2014-001/CEC-200-2014-001-SF.pdf

[14] See https://efiling.energy.ca.gov/getdocument.aspx?tn=222400

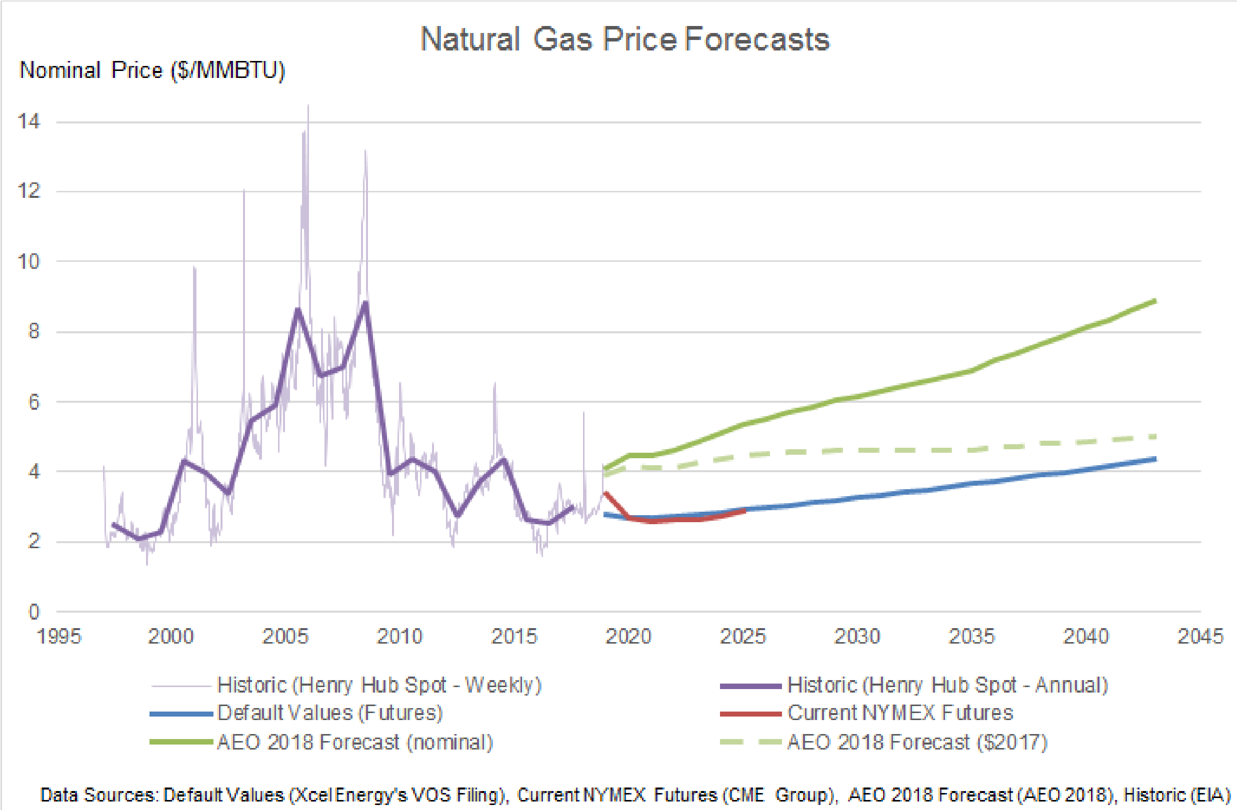

Figure 2. Historical Natural Gas Prices (Henry Hub), Current Futures Prices, Forecasts in the VOS Methodology, and the EIA's Annual Energy Outlook 2018 Forecast

If the natural gas price forecast in the VOS calculation derived from NYMEX futures prices in Table 8, column C, rows 7-25 are replaced with the natural gas price forecasts from the 2018 Annual Energy Outlook escalated at 2.25% to account for inflation, the levelized Value of Solar would be $0.1372 per kWh, a 31.2% increase relative to the original VOS submission (this value is inclusive of the two changes to the valuation of environmental benefits detailed in Sections 2.1 and 2.2).

It is an open question the extent to which the NYMEX-centered approach for approximating actual avoided costs reflect actual natural gas market exposures on the system. To answer this question would require information likely protected by trade-secret about how Xcel Energy and other MISO operators mitigate their exposure to natural gas price volatility. It would seem unreasonable to require a more detailed disclosure of Xcel Energy's financial position with respect to this risk. However, the risk mitigation steps that Xcel Energy (and other operators) have already taken are a critical input for understanding the true value of solar.

There is therefore a fundamental information asymmetry to calculating the hedge benefit of solar against natural gas price volatility for decreasing ratepayer risk. For example, if a natural gas purchaser has taken no steps to mitigate its exposure to natural gas price volatility (unlikely), ratepayers (who likely have a much lower risk preference) would be fully exposed to price volatility and there would be a large risk-hedging benefit to deploying more solar. In other words, the true value of solar depends critically on what other risk mitigation steps have been taken by natural gas purchasers, a quantity that is unknowable by the public. It is difficult to ascertain the extent to which the VOS methodology incorporates existing traders' risk positions into calculating the hedge benefit of solar in decreasing overall ratepayer exposure to natural gas price volatility.

The Commission in approving the VOS methodology in 2014 explicitly stated this risk mitigation as a goal of the avoided fuel cost calculation, "The Commission agrees with the Department that the three fuel cost component options appropriately capture the relevant avoided costs, including the avoided cost to utilities and customers of fuel price volatility." This is only the case if futures prices accurately reflect the risk premium the public (not the private utilities) would be willing to pay for decreased price volatility. One approach to capturing this hedge value would be to use common methods of developing confidence intervals based on futures prices. The EIA's Short Term Energy Outlook illustrates the large uncertainty implied by futures markets for natural gas prices. In the most recent iteration published on November 6, 2018, the 95% confidence interval for monthly natural gas prices in 2019 spanned $1.84 - 4.94 per MMBTU (see Figure 3 below extracted from the EIA report[15]).

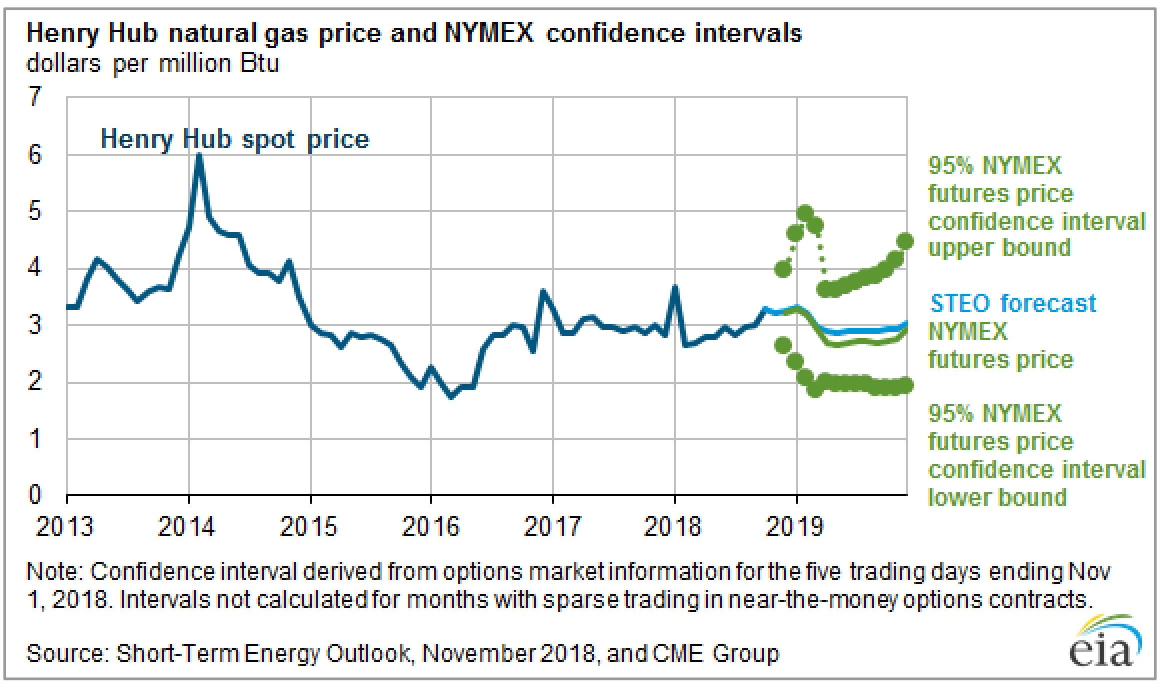

Figure 3. Confidence Interval Expressing Uncertainty in Forecasted Natural Gas Prices Based on Traded Futures Contracts (EIA, Short Term Energy Outlook for November 2018)

The Commission in approving the VOS methodology in 2014 explicitly stated risk mitigation as a goal of the avoided fuel cost calculation, "The Commission agrees with the Department that the three fuel cost component options appropriately capture the relevant avoided costs, including the avoided cost to utilities and customers of fuel price volatility." This is only the case if futures

[15] See https://www.eia.gov/outlooks/steo/pdf/steo_full.pdf

prices accurately reflect the risk premium the public (not the private utilities) would be willing to pay for decreased price volatility.

It is relevant that the Commission has discussed the importance of the VOS methodology accurately representing avoided natural gas fuel purchase costs without also reflecting the underlying volatility of natural gas futures prices. To ameliorate this concern, the Commission has expressed its satisfaction with the VOS methodology's approach to average several month's worth of futures prices. The Commission in approving the VOS methodology on April 1, 2014 stated:

> *The Department asserts that the modification makes projected fuel price values less subject to volatility in near-term natural gas prices, and then assumes, in the years beyond which there is useful future-price data, that the cost of natural gas will increase at the methodology's generally-applicable escalation rate…*

Natural gas price volatility continues to be a significant concern, despite the approach of averaging futures prices over several months. 2019 natural gas price futures have already increased substantially in the three months since Xcel Energy's initial VOS submission. The 2019 vintage VOS is based on average futures prices as traded from March 15, 2018 - August 15, 2018, calculating an effective natural gas price forecast for 2019 of $2.77 per MMBTU. However, prices as traded on November 20, 2018 would have given an effective natural gas price forecast for 2019 of $3.39 per MMBTU, a 22% increase. The observation that the VOS methodology would still pass through this level of volatility suggests that the current approach does not make project fuel prices "less subject to volatility in near-term natural gas prices."

4. Potential for Institutional Reform to VOS Update Process

Examining the VOS calculation process is an illuminating experience, and we would like to offer a number of observations and suggestions that we hope will be taken constructively to inform reforms to the VOS calculation process. We recognize that these suggestions may not all be adopted by the Public Utilities Commission, particularly without further legislative authority, but we raise these points in the hope that some of the procedures institutionalized now can be revisited. These recommendations can be viewed as signposts for either the Public Utilities Commission or the State Legislature to improve the shortcomings we see in the VOS revision process.

The VOS methodology is highly technocratic and relies on an extensive set of parameters, theoretical concepts, and assumptions. This complexity is derived from the nature of calculating avoided costs. Fundamentally, unlike other regulatory concepts, avoided cost concepts cannot be directly measured -- they are costs that were never incurred -- they are avoided! Avoided costs are a methodological construct that form the basis for negotiating fairness between system benefits and individual benefits.

There are additional parameters within the VOS that are worthy of reasonable debate, such as modelled versus observed capacity factor[16] and avoided distribution costs and locational values[17].

The science on determining grid value is growing rapidly, but the VOS methodology is rigid to new methods and data sources. The duty of providing alternatives and scrutiny on Xcel Energy's VOS calculations are mostly placed on public commenters and state personnel on an annual basis. This leaves little room for comprehensive review of the concepts and the process of the VOS. In Figure 4, we show that overall, the current VOS revision process has led to a 29% decrease in the VOS over the past four years (calculated based on the 2022 VOS) -- it's difficult to conceive that the actual value of solar has decreased by this much in a short time period. While Xcel Energy has provided brief rationales for each individual change (summarized in Figure 4), no explanation of the four-year change is provided. The public commenters, including Minnesota's concerned citizens, researchers, nonprofits, and renewable industry members, rely on the Commission and their own time to parse these complex changes in VOS valuation and probe Xcel Energy's justifications fully. Ultimately, increasing oversight may necessitate increased capacity at the Public Utilities Commission, something we would welcome[18].

[16] Solar capacity factors vary with a wide range of idiosyncratic factors that vary from year to year (e.g. solar irradiance). These factors could lead to significant divergence between short-run capacity factors and the average capacity factors over the lifetime of a solar project.

[17] Avoided distribution costs will vary over the lifetime of a project. Distribution grids evolve over time depending on load, and therefore are highly path dependent with new solar development. While some solar projects may not contribute to decreased distribution costs in the short-run, they may cumulatively lead to avoided distribution costs over the decades-long lifetime of projects.

[18] According to the Minnesota Department of Management and Budget, "Minnesota's state regulatory staff size remains well below states of comparable size, while its work-load is equal to other states of comparable population size." (Retrieved from https://www.mn.gov/mmb-stat/documents/budget/2018-19-biennial-budget-books/narratives-october-2016/public-utilities-commission.pdf)

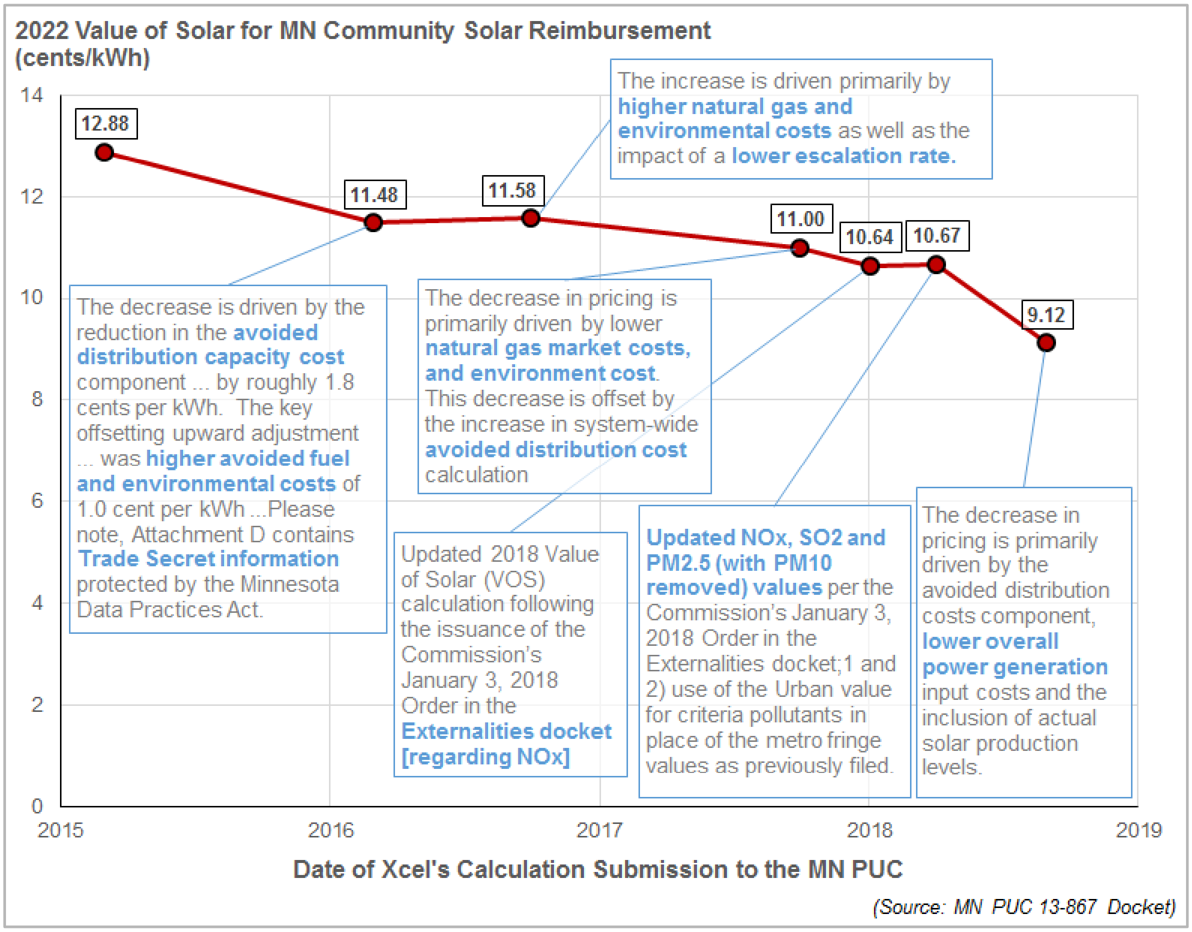

Figure 4: Xcel Energy's Value of Solar Calculation Revisions, Expressed in 2022 Values of Solar (MN PUC, Docket 13-867)

Here we reiterate the dual function that the VOS plays: on the one hand, it enables a fairer energy system by minimizing cross-subsidization across ratepayers, while on the other hand, it functions as the market-shaping tariff for solar garden development. Because of these dual functions, the VOS should balance accuracy with transparency. The community solar garden program is the largest form of generation competition for Xcel Energy. Bestowing Xcel Energy with the primary responsibility for developing each year's calculations of the VOS creates, at a minimum, a perception of a conflict of interest. A lower VOS would ostensibly create less competition for Xcel's generation portfolio.

To the extent possible, there should be more oversight to this process. At the least, Xcel Energy should have to provide justification for changes it makes on the VOS. Shifting the burden of proof to Xcel Energy rather than public commenters would help the public understand why the VOS changes. In particular, we would recommend that justification be provided for every parameter change in the VOS calculation relative to several years of previous parameter values. Documentation of assumptions and transparent data sources should be required and if parameter values rely on trade secret information, publicly verifiable alternative sources should be used as approximations instead. The Commission could also consider implementing a rolling-average of past VOS calculations, to smooth out any annual aberrations, as Austin Energy does in its VOS process[19].

Revisions to the VOS update process should embrace a balancing act that reflects the VOS's multiple purposes. Here we have replicated the National Renewable Energy Lab's conceptual figure demonstrating the considerations a VOS process should make[20].

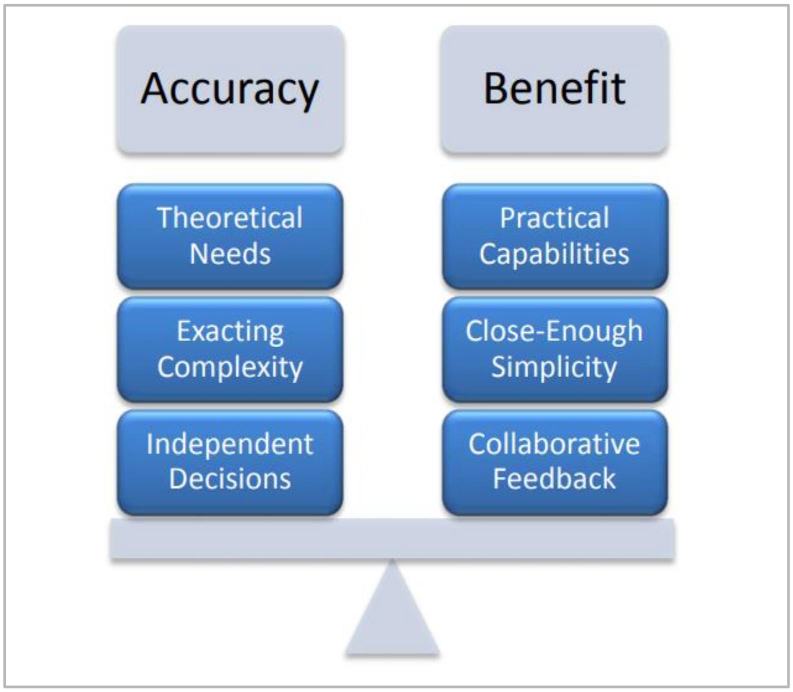

Figure 5. Schematic Representation of the Value of Solar Balancing Act

Minnesota's role as a leader in innovative energy technology implementation is shown through its embrace of a value of solar methodology. The state, its citizens, and this Commission benefit from a transparent and accurate value of solar calculation to support the program into the future. We close with reiterating Xcel Energy's comments on the Value of Solar Methodology, submitted on February 13, 2014,

> *To the extent changes are recommended to major planning assumptions, such as the long-term natural gas forecast and avoided carbon emissions value, those changes should be evaluated as part of a formal and comprehensive regulatory process that considers the broader implications of such changes.*

We have observed significant changes to the "major planning assumptions" in the Value of Solar calculation since Xcel's first submission in early 2015 and would concur with a recommendation for a "comprehensive regulatory process that considers the broader implications of such changes," which could include impacts on levels of solar development, ratepayer impacts,

[19] See https://emp.lbl.gov/sites/default/files/1._austin_vos_paper_final_2017-06-16.pdf

[20] See https://www.nrel.gov/docs/fy15osti/62361.pdf

environmental benefits to specific communities, grid resilience, community economic development, and more.

If you have any questions regarding the information or opinions provided in this filing, please contact me at 612-626-3292 or gabechan@umn.edu.

Sincerely,

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