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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	1
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:

Please provide a supplemental, publicly available description of the detailed methodology, including analytic equations where appropriate, for the streamlined hosting capacity analysis Xcel Energy performed.

As Xcel Energy notes on page 4 of the filing, transparency is a key requirement for a hosting capacity study. Xcel Energy's filing contains a limited description of the methodology chosen on pages 8-10 of the initial filing. While staff is not suggesting Xcel Energy's response needs to be as comprehensive, we offer for illustrative purposes only Chapter 4 of Pacific Gas & Electric Company's Integration Capacity Analysis for Distribution Resource Planning: Demonstration Project A – Enhanced Integration Capacity Analysis Final Report to the California Public Utilities Commission (December 27, 2016) as an example of a very thorough and detailed methodology description that is publicly available. Specifically, provide supplemental descriptions on, at a minimum, the following topics:

a. The steps in Xcel's methodology (as an example see pages 27-66 of the PG&E report referenced above);
b. Datasets, Tools, and Tool Capabilities (example from PG&E report on pages 34-36);
c. Power System Criteria and Calculation Techniques (example from PG&E report on pages 47-66)

Response:

Xcel's hosting capacity methodology can be broken down into five parts as follows:

1. Model feeders
2. Extract feeders to the Electric Power Research Institute's (EPRI) Distribution Resource Integration and Value Estimation (DRIVE) tool
3. Run Hosting Capacity Analysis
4. Compile Results

5. Map Results

1- Model Feeders

For the 2017 hosting capacity analysis, we created 1,047 feeder models in Synergi Electric, which is the distribution load-flow program we use. The information for these models primarily came from our Geospatial Information System (GIS), which contains segment by segment asset and connectivity data. This information is supplemented with data from our 2017 load forecast, and customer demand and energy data. These models contain information up to the feeder breaker, and do not consider any upstream elements such as substation transformers or transmission impacts. Once these models are extracted from GIS to Synergi, we run a series of "clean-up" scripts to complete the model assumptions and address any common issues that might be present in the data.[1]

This level of granularity in the models provides for a detailed hosting capacity solution. It is also important to note that where future DER or capacity projects are known but not yet in GIS, we adjust the models to reflect those changes. This provides an analysis that is more forward looking, based on the knowledge at the time. This part of the process is very time consuming, It took three engineers approximately three months, dedicated almost entirely, to complete the modeling.

2- Extract Feeders to DRIVE

We use a tool called Distribution Resource Integration and Value Estimation - Model A Interface (DRIVE-MAI) to extract every feeder from Synergi to DRIVE, after the models have been completed in Synergi. Feeder extraction varies from feeder to feeder due to the amount of data contained in the models for each, but generally this takes 5-10 minutes per feeder. DRIVE-MAI pulls the peak feeder data in, but also extracts the Daytime Minimum Load from the feeder based on an assumed percentage of peak value set within DRIVE-MAI. This provides the bounds needed to complete the analysis.

A small percentage of the extractions fail for various reasons. In these instances, an engineer must go back to the models in Synergi to try and determine what caused the failure. Typically, these are voltage-based errors that take some time to identify, troubleshoot, and ultimately correct before extraction can be finalized. This ensures another level of refinement takes place before the hosting capacity analysis begins.

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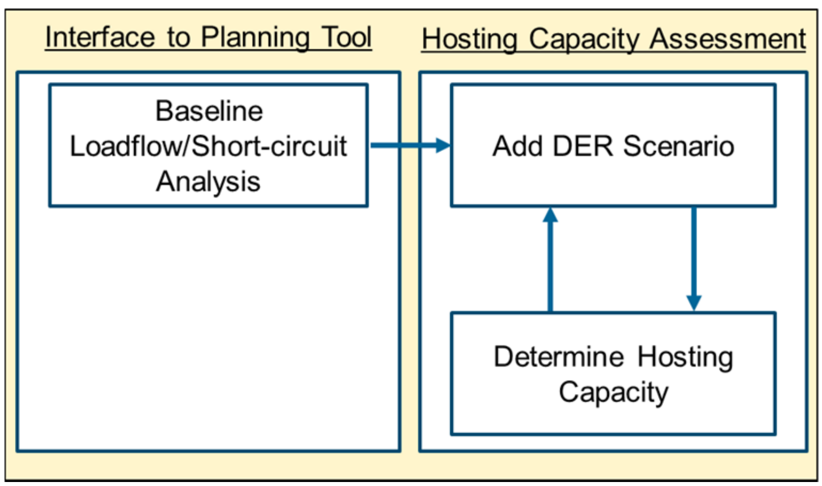
[1] For example, the GIS does not contain conductor spacing. We apply technical judgement during the clean-up process to provide these assumptions to the model.

3- Run Hosting Capacity Analysis
Once the models have been extracted, DRIVE can perform the necessary analysis. At this point, settings such as the Thresholds or type of DER expected, can be adjusted and the hosting capacity analysis is ultimately run. On average, it takes about 3-5 minutes per feeder to run the analysis. Once it has finished running, a report based on the DER allocation method is generated to establish the tabular results as seen in Attachment A of our hosting capacity report.

In the figure below, DRIVE-MAI is represented by the "Interface to Planning Tool" heading while DRIVE is represented by the "Hosting Capacity Assessment" heading. Within DRIVE, the Power System Criteria and Calculations Techniques are applied in the box labeled "Determine Hosting Capacity," while the "Add DER Scenario" box refers to the configurability of the type of DER allocation.

Figure 1: Illustrative Hosting Capacity Planning Interface and Assessment



Multiple other files are also generated in Microsoft Excel format that contain the detailed section-by-section hosting capacity results for each of the eleven thresholds, regardless of the amount of thresholds desired (six thresholds chosen for this analysis).

4- Compile Results
In order to make the results meaningful, the Excel outputs from DRIVE need to be filtered and compiled from an individual feeder file to larger files categorized by region. Currently, this part of the process is very manual. It takes approximately one month for an employee to accurately pull together this data in a way that is suitable for mapping and the tabular results.

5- Map Results

Once the results are accurately compiled, we can begin visual mapping based on a segment-by-segment analysis. We use ArcGIS Online to publish the results. By mapping the results, end-users can better identify available hosting capacity - not only on the overall system, but also the location(s) on each particular feeder.

Datasets and Tools

We use a number of tools and datasets in completing the hosting capacity process. The tools are the software interfaces that are used to build, calculate, analyze, etc. The datasets are collections of information used within the tools to provide valuable and more refined outcomes.

Datasets

- **GIS:** Contains location-specific information about system assets and components allowing us to view, understand, question, interpret and visualize data in many ways that reveal relationships, patterns, and trends in the form of maps.
- **Load Forecasts:** Provides per phase feeder load forecast information that is used to populate feeder models.
- **Supervisory Control and Data Acquisition (SCADA):** Monitors and collects system performance information for Feeders and Substation Transformers
- **Customer Load and Energy Usage:** This data is brought into the models to help better replicate and "tune" them to what is occurring in the field.
- **Distributed Generation (DG) Queue:** Utilized to populate the models with accurate future DG projects not yet in service.

Tools

- **DNV-GL Synergi Electric:** Contains a geospatially accurate model of the electric distribution feeder system with known conductor and facility attributes such as ampacity, construction, impedance and length to simulate the distribution system and run power flow solutions.
- **ITRON Distribution Asset Analysis:** System of record for historical peak feeder and substation transformer load information that we use to evaluate historical load growth and weather adjustments to match prior peaks and identified known growth to establish a forecast for 1+ years out
- **DRIVE:** Using actual Company feeder characteristics, DRIVE considers a range of DER sizes and locations in order to determine the minimum and maximum range of hosting capacity by screening for voltage, thermal, and protection impacts.
- **DRIVE-MAI:** The interface that pulls the necessary model characteristics from Synergi for DRIVE to accurately perform hosting capacity analysis.

- **ESRI ArcGIS Online:** Tool used to publish the hosting capacity heat map and make available on the Xcel Energy website.

Power System Criteria and Calculation Techniques

We rely on EPRI's *Distribution Planning with Distributed Energy Resources: Systemwide Assessment – Final Collaborative Report* (2017) to explain each of the analyses involved in this part of the process. The provided Figures are also directly from this report.[2]

As outlined in Table 2 of our 2017 filing, we used six of the eleven thresholds/criteria to determine hosting capacity on our system. The hosting capacity assessment is performed independently for each of these criteria. Each one is explained in more detail below.

Primary OverVoltage. Primary overvoltage hosting capacity considers adverse impact to occur when DER increases the feeder voltage profile beyond an upper voltage limit. For example, the upper voltage limit may be the upper ANSI limit of 1.05 Vpu. However the value can be different based on the utilities planning criteria. For instance, the threshold may be 1.04 Vpu to account for voltage rise across services or perhaps for conservation voltage reduction.

DRIVE traces the top of the voltage profile, as shown in Figure 3 below, to define the maximum voltage on the feeder. The impedance of each node is also considered as shown by the x-axis in the figure. As hosting capacity is examined for different DER scenarios, each DER scenario will describe the DER current across the feeder. The DER current along with the impedance determine the voltage change. In turn, the hosting capacity is determined when the voltage change plus the maximum feeder voltage exceeds the overvoltage limit. Voltage regulation is not examined in this analysis, thus the overvoltage may only be temporary rather than sustained.

The voltage-based impact assessment examines the voltage change along a feeder approximated as:[3]

Figure 2: Voltage Based Impact Assessment Calculation

$$V_{change}{}^{y} \approx \sum_{n=1}^{y} I_R^n \cdot dR^n + I_X^n \cdot dX^n$$

[2] Pages 4-4 – 4-8.

[3] Electric Power Distribution Handbook. T.A. Short, 2004, page 236.

Where I_R is the real DER current and I_X is the reactive current. The variables *d*R and *dX* are the incremental feeder short-circuit impedances. The variable *n* defines each location on the feeder, and *y,* defines the cumulative voltage change to that location on the feeder. This simple formula is the basis to assess the impacts of real and reactive power output from DER. The resulting voltage change will impact all voltage-based hosting capacity assessments.

The use of the maximum voltage across the feeder ignores lateral branches with lower voltage, however, during minimum load when overvoltage is more commonly a concern, there is typically much less voltage drop on all laterals and the maximum voltage profile is sufficient. In some cases, when the overvoltage may occur during peak load, those overvoltage locations are typically near the substation or a mid-line voltage regulator. In those cases, the overvoltage does not occur on a lateral branch, but on a regulated mainline element that is impacted by DER anywhere downstream.[4]

Figure 3: Primary Overvoltage Analysis

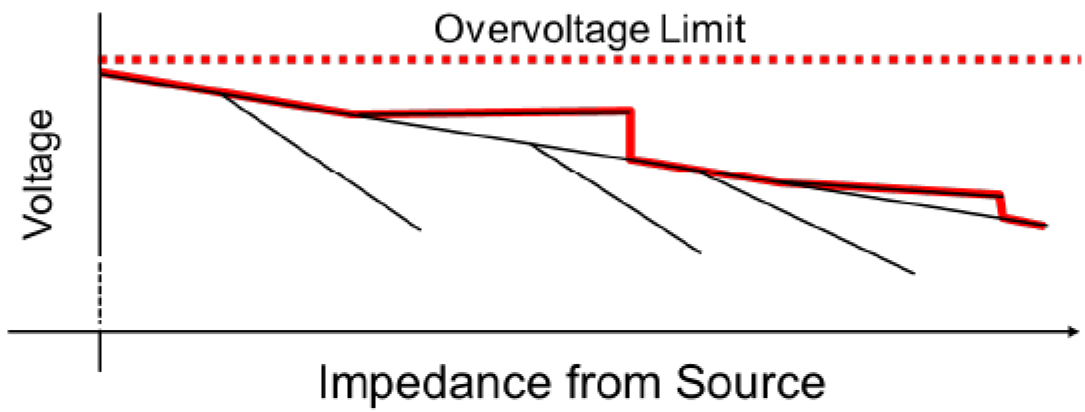


Figure 4-3
Primary Overvoltage Analysis

Primary Voltage Deviation. Primary voltage deviation hosting capacity determines the amount of DER that can be accommodated before voltage changes by more than the allowable threshold. Unlike primary overvoltage, the underlying voltage profile is not needed to determine the hosting capacity for the different DER scenarios. The allowable change is constant across the feeder as shown in the Figure 4 below. DER scenario, associated currents, and the impedance for the DER scenario are involved to determine hosting capacity.

[4] We expect in the next revision of DRIVE, the voltages to each specific location, including single-phase locations, will be addressed without the use of the maximum voltage profile.

Figure 4: Primary Voltage Deviation Analysis

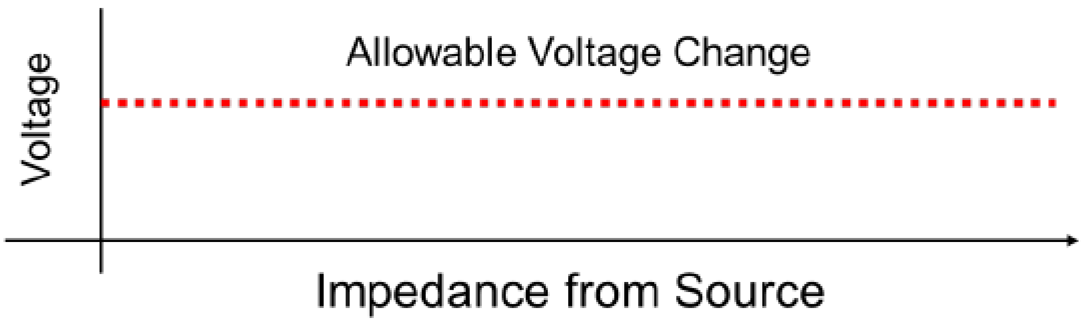


Figure 4-4
Primary Voltage Deviation Analysis

Regulator Voltage Deviation. Regulator voltage deviation for hosting capacity stems from the primary voltage deviation analysis. However, for this metric the hosting capacity assessment is restricted to the regulated node. This node may be an actual node on the feeder or a fictitious node characterized by line drop compensation. The hosting capacity for this metric determines the amount of DER that can be accommodated before the regulated node would experience a voltage change leading to excessive regulator operation. An example of this analysis functionality is shown in Figure 5.

Figure 5: Regulatory Voltage Deviation Analysis

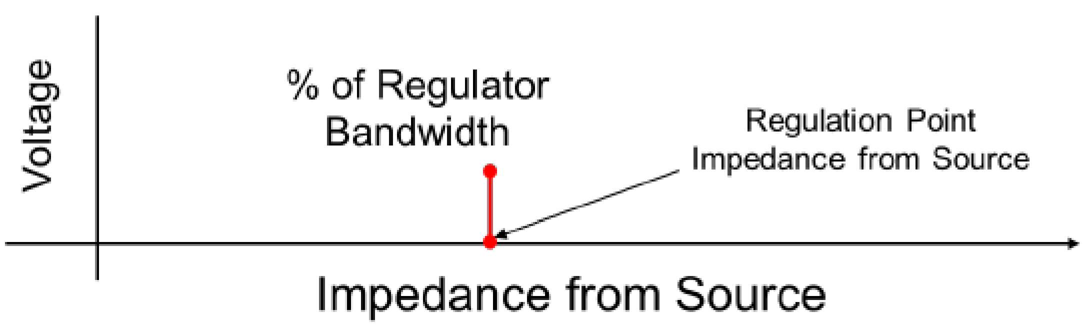


Figure 4-5
Regulator Voltage Deviation Analysis

Thermal for Discharging DER. Thermal hosting capacity determines the amount of DER that can be accommodated before thermal violations begin to occur. The analysis is based on the ratings of all elements on the feeder and the baseline power flow. To determine the hosting capacity at any particular node, all elements upstream must be examined for thermal violations. This involves walking the feeder from each node back to the source.

Thermal hosting capacity is determined for Generation and Load (*Note: the Company did not determine thermal for load*). Thermal for generation hosting capacity examines the thermal limitations when generating power. This is influenced by the minimum load power flow. The thermal hosting capacity could occur when the DER is larger than any upstream elements rating plus the elements minimum load. Thermal for load hosting capacity examines the thermal limitations when drawing power from the sources such as for storage. This is influenced by the peak load power flow. The thermal hosting capacity could occur when the DER is larger than any upstream elements rating minus the elements maximum load.

Breaker Relay Reduction of Reach. Breaker relay reduction of reach hosting capacity determines the amount of DER that can be accommodated before the breaker relay loses visibility of the feeder-end. The analysis does not consider the actual protection settings of the feeder; rather, the analysis uses a user-defined percent allowable reduction in breaker fault current to determine hosting capacity. A reduction of this magnitude is meant to alert the planner to look further into protection settings.

The analysis is based on reduction of source fault current due to a remote feeder fault as illustrated in Figure 6 below. The injection of DER current anywhere between the source and the feeder-end will reduce the source fault current. The reduction in source fault current can depend on DER location. However, when the DER is inverter type (constant current injection), the reduction in source fault current is relatively constant regardless of DER location. When the DER fault current is dependent on impedance to the fault, higher hosting capacities can occur near the feeder head because those DER fault currents would be lower for the remote feeder fault. Thus for the worst-case scenario, in DRIVE v1.1 (the version underlying our 2017 hosting capacity analysis), the hosting capacity is assumed location independent and based on inverter type DER.

This hosting capacity also applies to reclosers in the feeder as well as the breaker. If there is a recloser mid-feeder and the DER is between the end of the feeder and the recloser, a similar percent reduction in source fault current would occur. However, if the DER is upstream from the recloser, the recloser will experience approximately the same fault current while only the breaker would see the reduction.

Figure 6: Breaker Relay Reduction of Reach Analysis

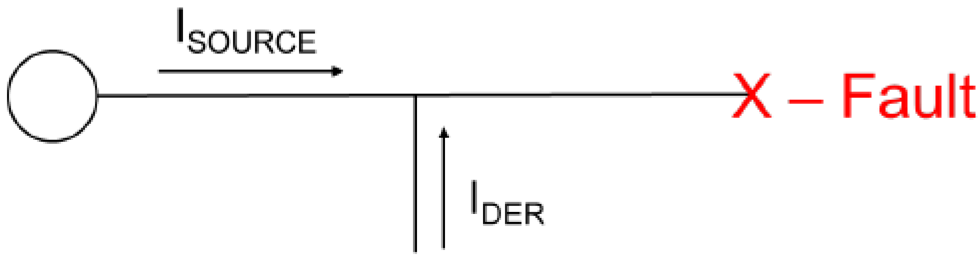


Figure 4-7
Breaker Relay Reduction of Reach Analysis

Additional Element Fault Current. Additional Element fault current hosting capacity determines the amount of DER that can be accommodated before the DER could cause an adverse increase in the fault current on a nearby protection element. Actual protection settings are not examined, so an allowable percent change threshold is used to gauge when protection settings might be impacted and further investigation is needed.

The issue is based on the increase of total fault current (Source plus DER) through an element due to a feeder fault. The scenario where fault current increases only occurs when the fault DER, and protection element are all in the same proximity as shown in Figure 7 below. The protection element has to be downstream from the DER and source to see the increase in fault current. If this scenario does not occur, such as if the fault is further away from the DER, the source fault current can decrease more than the DER injects (similar to the breaker reduction of reach issue). It is assumed that there are many protection elements within the feeder for which this scenario could apply.

Figure 7: Additional Element Fault Current Analysis

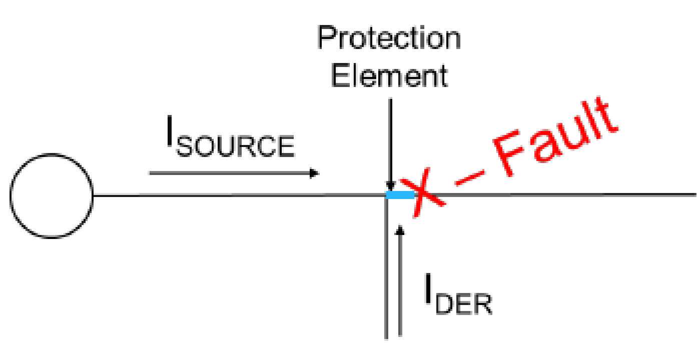


Figure 4-8
Additional Element Fault Current Analysis

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Xcel Energy

Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	2
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
Similar to how Xcel Energy provided definitions in the 2016 Hosting Capacity Analysis filing, please provide definitions of the terms "Minimum Hosting Capacity" and "Maximum Hosting Capacity" as those terms are used in Xcel's November 1, 2017 report beyond the description on page 11 of the initial filing. Staff's understanding is as follows, please confirm or correct these term descriptions:

a. "Maximum Hosting Capacity" refers to the maximum amount of DER generation that can be interconnected on a feeder provided it is located in a suitable location. The associated "Max Limiting Factor" applies to that specific location.
b. "Minimum Hosting Capacity" refers to the maximum amount of DER generation that can be interconnected anywhere on a feeder, irrespective of location. The associated "Min Limiting Factor" applies to a specific point on the feeder where generation location becomes a concern.

Response:

The definitions indicated above are correct, and are relevant for the tabular hosting capacity results. We discuss how these definitions are not relevant for the heat map view of hosting capacity, which we newly provided with our 2017 analysis, in our response to MPUC Information Request No. 3.

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	3
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
Please explain why the "Minimum Hosting Capacity" is plotted on the heat maps (Introduction paragraph 3, Figure 3, and online tool at https://www.xcelenergy.com/working_with_us/how_to_interconnect), rather than the "Maximum Hosting Capacity." (We note that both the Minimum and Maximum Hosting Capacity are provided in the accompanying spreadsheets.) Please also provide a heat map of Maximum Hosting Capacity.

Response:
The *Minimum Hosting Capacity* and *Maximum Hosting Capacity* terms are only relevant when discussing hosting capacity without geographical representation, as is done in the tabular results accompanying the heat map. In our heat maps, the hosting capacity changes by segment, as indicated by gradient color changes – and so the user can see various hosting capacities along the feeder. Therefore, in visually mapping the hosting capacity at every location on the feeder, the minimum and maximum, as well as all amounts in-between, hosting capacities are shown.

It is possible that initial limits flagged by DRIVE may not require system upgrades. A detailed study, as part of our interconnection process, may show that more hosting capacity is available at a particular point. In this way, the value at each location could be considered as the minimum hosting capacity, though we believe it most appropriate to refer to this value simply as the "hosting capacity." When we refer to the hosting capacity at any location, the value indicated is intended to convey the amount of Distributed Energy Resources (DER) capacity that could be installed before any electric system limit requires further review that could possibly trigger an upgrade.

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	4
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
Please confirm that the heat maps do not show the hosting capacity for different sections along a feeder. If confirmed, please provide updated heat maps with hosting capacity by feeder segments or a rationale for why the Company has chosen not to do that level of analysis.

Response:
Feeder segments are determined in our Geospatial Information System (GIS) as the distance between two nodes, which generally occur at any change in asset type or at an asset addition on the system. For instance, a segment could be the line between two poles, or the section between a switch and a change in the conductor type. Consequently, the size of each segment is unique and can vary widely. We conducted our hosting capacity analysis on a segment-bysegment basis, with each feeder having hundreds to thousands of segments.

In the example below, we show a single feeder that indicates varying levels of hosting capacity along the feeder shown by color variations. Within each level are many segments with small changes in hosting capacity occurring across the level. We chose to not show every segment, but rather to focus on the significant levels of change.

Figure 1: Excerpt from MN Hosting Capacity Heat Map

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	5
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
Xcel Energy states under "Advanced Inverter Settings" (page 3) that the power factors of existing and anticipated DERs are modeled, and that new DERs are modeled, with a fixed power of 0.98 leading.

a. Please clarify whether Xcel included other advanced inverter controls in the analysis, including:
   1. Volt/Watt and Volt/Var controls for regulating voltage
   2. Voltage ride-through and frequency ride-through controls to cope with system disturbances
b. If the analysis did not include these other advanced inverter controls, please explain how including these controls may affect the results of the analysis. Additionally, indicate whether other advanced inverter controls are able to be considered in the DRIVE model today. If not, is Xcel Energy aware of whether the Electric Power Research Institute (EPRI) intends to incorporate those considerations in future software iterations of the DRIVE model?

Response:
The voltage-active power (Volt-Watt) and voltage-reactive power (Volt-VAr) control modes are not currently available in the DRIVE analysis.

This hosting capacity analysis did not include response to abnormal conditions, such as voltage or frequency ride-through. Hosting capacity typically analyzes steady state or quasi-steady state (*static*) conditions, which would not capture the time scales associated with brief system disturbances and DER ride-through capabilities. We are not aware of any hosting capacity analysis that includes ride-through capabilities, as these would typically be studied using *dynamic* analysis software typically found in transmission engineering.

If the Volt-VAr function were used in hosting capacity analysis, the results would largely depend on how the function was used. The same is true for the fixed power factor of 0.98 that was used in the 2017 results. The DRIVE tool has the capability to set a lower power factor, which is likely to increase hosting capacity in some locations. We did not choose a lower power factor because trade-offs exist. For example, increased reactive power flow and losses. We have and will continue to use a lower power factor, such as 0.95, as the result of a detailed study where the trade-offs can be reviewed.

The situation is similar for Volt-VAr A default Volt-VAr curve may provide similar results to the fixed power factor in many locations. Volt-VAr may be an effective tool for managing voltage in contingency situations, but the DRIVE tool currently only looks at normal configurations. Similarly, the Volt-Watt function is aimed at resolving voltages that occur under abnormal conditions. The Volt-Watt function actually curtails real power output (DER capacity) in order to bring voltage back into the acceptable range. While this may be an important tool for utilities to manage DER in abnormal configurations, the Volt-Watt function is not anticipated to increase hosting capacity under normal configurations.

A complete set of advanced inverter functions are not currently available as part of the DRIVE tool today. However, at a recent DRIVE user group meeting that included multiple utilities, this was identified as a top future enhancement for the tool going forward. EPRI has committed to expand these applications, where valuable, in future releases. Currently the DRIVE tool can analyze non-unity constant power factor mode, which is one of the advanced inverter functions in the draft interconnection standard IEEE 1547.

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	6
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
Xcel Energy set a limit of 3% for "Primary Voltage Deviation" when the DER output changes from full to zero output. This is intended to represent the effect of a cloud passing over solar PV panels on a sunny day and rapidly reducing their output to zero and is based on a methodology described in Xcel Energy's April 26, 2017 Compliance Filing on Transition to Incorporating the Standards of IEEE 1453 in Docket No. E002/M-13-867.

a. Does Xcel apply the DER output change only to the new PV being studied for hosting capacity as the 3% limit is described in the April 26, 2017 filing, or to both new and existing PV which would likely change output simultaneously? If the latter, please describe why the 5% for all feeder DG facilities tripping described in the April 26, 2017 is not appropriate in this instance.
b. Please explain how Xcel modelled the wide area effect of a cloud that covers several feeders on primary voltage deviation. If Xcel did not perform such modelling, please describe the directional effects on such deviations.

Response:
At this time, the DRIVE tool is only capable of applying one voltage fluctuation limit – the individual (3%) or aggregate (5%) threshold – for a given analysis. We note that we intended to provide hosting capacity results with the individual 3 percent threshold for a single Distributed Energy Resource (DER) changing from full-on to full-off. However, upon reexamining the tool's default assumptions we found that the voltage change was equivalent to 5 percent for all DER on the feeder changing from full-on to full-off.

Our intent is to maintain a consistent hosting capacity methodology as described in our April 26, 2017 filing on voltage fluctuation in Docket No. E002/M-13-867. Of significance, is the fact that in our analysis of approximately 800,000 feeder segments, less than 1 percent of them violated the 5 percent Voltage Deviation threshold. By comparison, the Primary Over-Voltage threshold was the limiting violation on nearly 50 percent of the segments. Although important, this shows that voltage deviation has a small impact on end results and very rarely restricts hosting capacity or dissuades potential interconnections.

Our voltage fluctuation adoption does not contemplate wide-area cloud cover causing the types of voltage fluctuation described in IEEE 1453 – namely Rapid Voltage Change (RVC) and flicker. The time scales associated with wide-area cloud cover are not in scope of IEEE 1453.

The cloud cover impact that we analyze in detailed studies relates to a single PV unit reducing real power output by 75 percent with an allowable voltage change of 1.5 percent at any voltage regulator device. This translates to a 2 percent change for full-on to full-off of the single unit, as measured at the voltage regulator. Individual PV units that could change the feeder voltage by more than 1.5 percent during cloud cover have the potential to cause increased voltage regulator tap changes, which in turn can cause visible flicker and voltage fluctuation.

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	7
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
According to Xcel Energy, the "Large Centralized Methodology" focuses on three phase lines "which generally have more capacity and better align with the types of installations we are seeing on our system" (page 11). Please explain how Xcel Energy's analysis handles small and distributed PV installations (including existing installations, some not on three phase lines). Please explain how, or if, future iterations of the DRIVE model could adapt to differing levels of DER installations (small and large).

Response:
As noted in our Report, our 2016 analysis used existing functionality inherent to the DRIVE tool to analyze hosting capacity using the "Small Distributed" methodology. This methodology aligns with "small and distributed installations." In our 2017 analysis, we used the Large Centralized methodology due to the proliferation of large solar projects on our system. So, DRIVE is able to tailor the analysis to fit the desired need.

However, if "Small Distributed" is used, it should be understood that our present hosting capacity analysis is on our Primary voltage system where the larger barriers exist for installing DER, both in cost and size; the Secondary system is not modeled, and consequently cannot be analyzed. Typically, if small installations encounter electrical violations, it is on the secondary side of the transformer and would not be captured by the hosting capacity analysis – even with the "Small Distributed" methodology.

In order to provide meaningful hosting capacity results at the customer level, we would need to undertake a major initiative to physically collect all of the Secondary information needed for modeling, which would include service line types and distances for all of our customers. This would likely take years to accomplish and be accompanied by a large financial investment. Beyond the data gathering, we would also need to map and alter our tools to incorporate this new information into our analysis.

Existing large and small PV installations, as well as other generation sources, are captured in the models, regardless of what hosting capacity analysis methodology is chosen. These installations could be single phase and may affect the overall hosting capacity of the feeder. At this time, we continue to believe that the Large Centralized Methodology provides the most usefulness and is the most reasonable methodology given the state of the PV industry in Minnesota, the asset information available, and the value in the final results.

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Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:

Xcel Energy states that, "Due to the nascent nature of the energy storage market in Minnesota, we excluded energy storage load characteristics from our analysis. However, in the future we plan to monitor the ability of our hosting capacity tool with regard to energy storage, and work to extract value where it exists" (page 7). Please quantify the amount of existing energy storage on Xcel's system (number of storage installations, megawatt capacity) and provide a forecast of the increase in energy storage, including both battery storage and electric vehicles, over the next five years and the next 10 years.

Response:

Battery storage

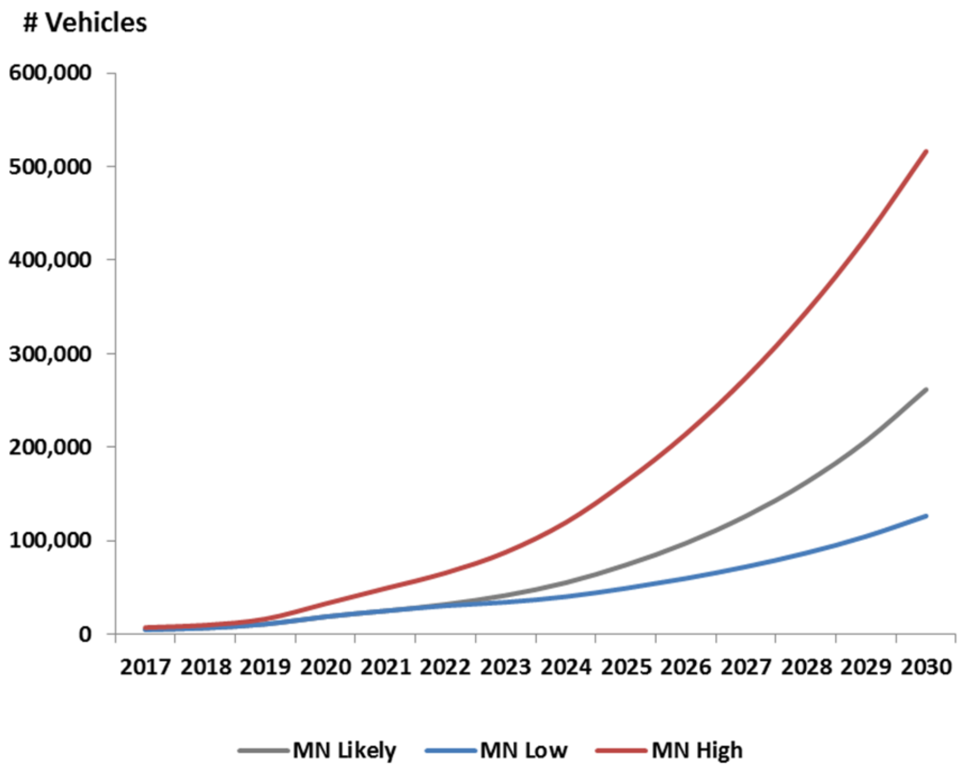
We have received 18 applications for battery storage systems with rated power of 115 kilowatts (kW). Only six of these projects (3 kW) have reached the completed stage of the application process. At present, we do not maintain a forecast for battery storage.

Electric vehicles

We have a Low, High, and Likely forecast of electric vehicle counts in our Minnesota service territory, which is based on an internally-developed methodology that incorporates both economic payback and Bass diffusion (technology adoption) model. The scenarios are created based on gasoline prices to derive adoption estimates. The likely scenario is formulated by taking a weighted average adoption of the economic and Bass diffusion models[1]. See Figure 1 below.

[1] The Bass Model or Bass Diffusion Model was developed by Frank Bass. It consists of a simple differential equation that describes the process of how new products get adopted in a population. The model presents a rationale of how current adopters and potential adopters of a new product interact. The basic premise of the model is that adopters can be classified as innovators or as imitators and the speed and timing of adoption

Figure 1: Forecast of EV counts under Low, High, and Likely EV Penetration Scenarios



Based on these forecasts of EV penetration, and 4,500 kWh electricity consumption per EV per year (15,000 miles per year/3.34 miles per kWh), we have prepared corresponding forecasts of electricity usage for EV charging. See Table 1 below.

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depends on their degree of innovativeness and the degree of imitation among adopters. The Bass model has been widely used in forecasting, especially new products' sales forecasting and technology forecasting.

Table 1: Forecast of kWh Demand for EV Charging under Low, High, and Likely EV Penetration Scenarios

Year	MN Low	MN High	MN Likely
2017	21,575,114	32,286,120	21,575,114
2018	30,117,346	43,802,972	30,117,346
2019	48,803,506	73,498,543	48,803,506
2020	84,688,764	146,855,837	84,688,764
2021	112,383,989	220,711,199	112,383,989
2022	137,297,885	295,101,150	143,889,930
2023	154,408,634	394,969,341	186,939,482
2024	180,710,079	537,813,438	248,173,284
2025	221,322,419	734,531,243	333,473,408
2026	268,847,408	963,662,566	438,226,313
2027	324,729,120	1,234,217,479	568,486,309
2028	390,727,274	1,549,025,399	729,855,368
2029	470,624,564	1,910,181,443	929,502,844
2030	569,060,385	2,323,452,416	1,177,383,770

Note that these are estimates of annual usage; they do not speak to the time-based charging profile of the vehicles. It is also important to note that we do not foresee any significant usage of EV batteries as dispatchable storage in the near future.

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Date: January 22, 2018

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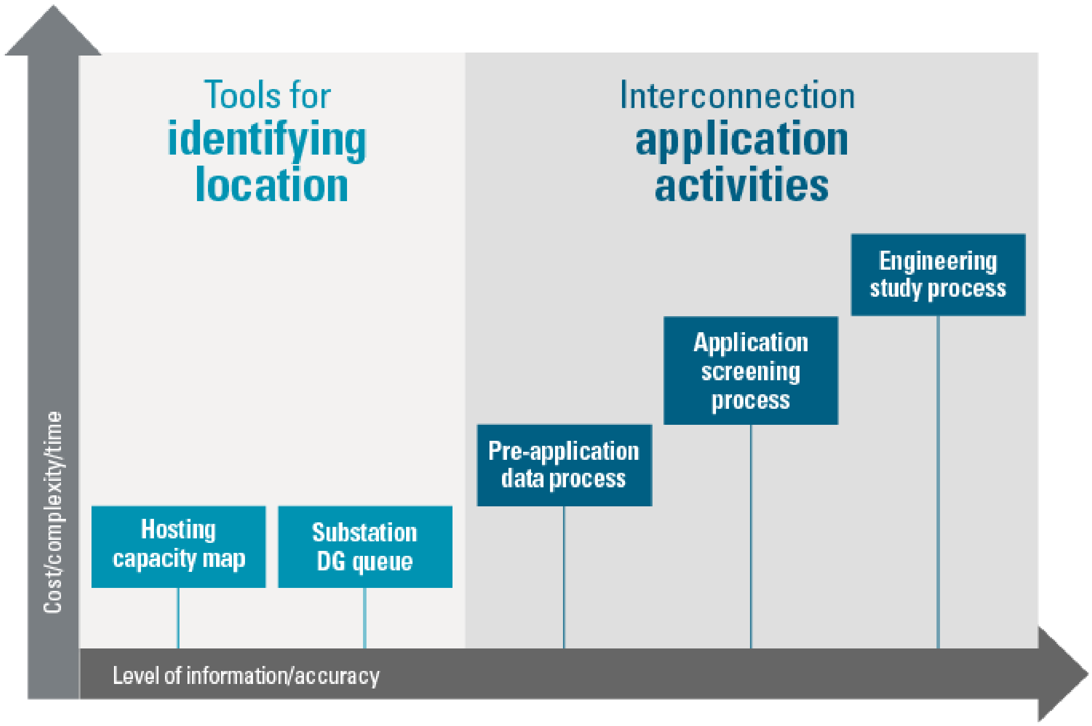
☒ **Public Document**

Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	9
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
In Xcel Energy's view, how can hosting capacity analysis be used to inform or improve the utility's interconnection process?

Response:
Xcel Energy considers hosting capacity analysis and the resulting hosting capacity maps and data tables a preliminary step in the interconnection process. See the below graphic, which shows how we envision our hosting capacity tools fitting into the interconnection process. The hosting capacity tools are publicly available at no cost via our website, and provide a indication of our distribution system's ability to support distributed energy resources. Areas with a higher level of hosting capacity allow customers or developers to quickly identify potential interconnection sites that will likely have minimal impact on Xcel Energy's distribution system, thereby resulting in lower installed costs. Once a prospective interconnection location has been chosen, developers or individuals can enter into the interconnection process for increased levels of detail and refined estimates of system impacts and costs.

Figure 1: Steps Towards Interconnection



Preparer:	John Harlander
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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	10
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
In Xcel's Energy's view, how can hosting capacity analysis be used to inform or improve the utility's biennial distribution system planning process?

Response:

We clarify that we understand this question to be asking about our biennial (proposed in our November 1, 2017 report in Docket No. E002/M-17-776 to be annual for the foreseeable future) reports on Grid Modernization and Hosting Capacity.

We discussed potential improvements we will be able to make in our planning processes as a result of grid modernization in the Commission's inquiry regarding distribution planning in Docket No. E999/CI-15-556. As discussed in our June 21, 2017 response to the Commission's Notice in that docket, we expect the Advanced Distribution Management System (ADMS) and other functionalities it will enable will provide improved awareness of distributed energy resources (DER) influences on the grid, and accurately model all elements in the network (including DER), for better forecasting and more insight for system planning. Distribution Planning will need additional tools that would interface with the advanced grid initiatives to allow our planning and forecasting to evolve as our system incorporates these new technologies and added functionality. However, we would expect that the additional grid insights and planning improvements from our grid modernization efforts will translate to improved information for third parties, perhaps including through our hosting capacity analysis, such as in terms of where to potentially connect to the system, as well streamlining our review of interconnection applications.

At this time, we view our hosting capacity analysis as tool for external parties to understand potential areas in which to connect DER. We believe whether the

Company uses the hosting capacity view of its system into its planning processes may raise a policy question – whether the Company should undertake system upgrades or changes in order to expand hosting capacity to accommodate greater levels of DER, where capacity may be more limited at present.

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Date:	January 22, 2018

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Xcel Energy			
Docket No.:	E002/M-17-777		
Response To:	MN Public Utilities Commission	Information Request No.	11
Requestor:	Tricia DeBleeckere and Michelle Rosier		
Date Received:	January 11, 2018		

Question:
In Xcel Energy's view, how can hosting capacity analysis be used to inform or improve the utility's grid modernization investments?

Response:
Please see our response to MPUC Information Request No. 10.

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