

**STATE OF MINNESOTA**  
**OFFICE OF ADMINISTRATIVE HEARINGS**  
**FOR THE MINNESOTA PUBLIC UTILITIES COMMISSION**

**IN THE MATTER OF THE PETITION OF NORTHERN STATES POWER COMPANY TO INITIATE A  
COMPETITIVE RESOURCE ACQUISITION PROCESS**

**OAH DOCKET No. 8-2500-30760, MPUC DOCKET No. E002/CN-12-1240**

**REBUTTAL TESTIMONY**

**OF**

**R. THOMAS BEACH**

**PRINCIPAL,**

**CROSSBORDER ENERGY**

**ON BEHALF OF**

**GERONIMO ENERGY, LLC**

**OCTOBER 18, 2013**

**Exhibit \_\_\_\_**

**REBUTTAL TESTIMONY OF R. THOMAS BEACH**

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1 **I. INTRODUCTION**

2 **Q: Please state your name.**

3 A: My name is R. Thomas Beach.

4 **Q: Have you previously provided testimony in this proceeding?**

5 A: Yes. I provided direct testimony on behalf of Geronimo Energy, LLC.

6 **Q: Have you reviewed the direct testimony filed by the other parties in this proceeding**  
7 **on September 27, 2013?**

8 A: Yes.

9 **Q: What is the purpose of your rebuttal testimony?**

10 A: The purpose of my rebuttal testimony is to respond to Xcel Witness, Mr. Steve Wishart,  
11 and Department Witness, Dr. Stephen Rakow. Specifically, my rebuttal testimony  
12 addresses statements made by Mr. Wishart and Dr. Rakow regarding accredited capacity  
13 for solar and discusses other quantifiable attributes of solar not reflected in either the  
14 Department's or Xcel's Strategist models.

15 **II. ACCREDITED CAPACITY**

16 **Q: On p. 34 of Mr. Wishart's Direct Testimony, he asserts that "recent analysis" by the**  
17 **Company indicates that Geronimo's 71 MW accredited capacity value is "likely to**  
18 **be higher than the actual credit that solar projects will receive in the future." What**  
19 **is your response to this assertion?**

20 A: I believe that this statement is misleading and that the record on this point should be  
21 clarified. Geronimo issued an information request to Xcel asking for a reference to the

1 Company's "recent analysis."<sup>1</sup> According to Xcel, the source of that statement was  
2 Xcel's May 1, 2013 Solar Effective Load Carrying Capacity Capability ("ELCC")  
3 Study.<sup>2</sup> It is important that the ALJ and Commission understand that Xcel's May 1, 2013  
4 ELCC Study should not be used to reach any conclusions regarding the expected  
5 accredited capacity of Geronimo's Solar Proposal because the study is preliminary and  
6 inaccurate. Xcel itself recognized several errors in its May 1, 2013 ELCC Study and is in  
7 the process of updating the ELCC Study.<sup>3</sup> As described below, if applied appropriately,  
8 the updated results released to date appear to support an accredited capacity for  
9 Geronimo's Solar Proposal that is very close to the value that Geronimo has derived  
10 using the MISO accreditation method. Moreover, there is presently no basis to conclude  
11 that MISO will use Xcel's ELCC values to calculate accredited capacity, even after Xcel  
12 completes its updates to the ELCC Study.

13 **Q: Please explain why you state that Xcel's May 1, 2013 ELCC Study is "preliminary**  
14 **and inaccurate".**

15 A: As I noted above, Xcel is currently in the process of updating the May 1, 2013 ELCC  
16 Study.<sup>4</sup> In August 2013, Xcel provided an update to interested stakeholders that  
17 significantly increased the ELCC relative to the maximum AC output of the units  
18 studied.<sup>5</sup> Based on this new information, the difference between Geronimo's estimated

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<sup>1</sup> Geronimo IR No. 3 to Xcel, Response attached as Geronimo Schedule RTB-1 (Beach Rebuttal).

<sup>2</sup> *Id.* The full text of Xcel's May 1, 2013 ELCC study is available in eDockets (ID# 20135-86585-01) in Docket No. E002/CI-13-315 and was not repeated in the attached schedule.

<sup>3</sup> Xcel's Solar ELCC Study Update August 14, 2013 ("ELCC Study Update"), slides 20-29, attached as Geronimo Schedule RTB-2 (Beach Rebuttal).

<sup>4</sup> Geronimo IR No. 5 to Xcel, Response attached as Geronimo Schedule RTB-3 (Beach Rebuttal).

<sup>5</sup> ELCC Study Update, slides 20-29.

1 71 MW and the updated ELCC Study Update for single axis tracking systems is less than  
2 5 percent.

3 **Q: Can you walk through how the updated ELCC Study Update results, applied the**  
4 **Solar Proposal, would come within 5% of Geronimo’s estimated MISO accredited**  
5 **capacity for the project?**

6 **A:** Certainly. Xcel released an ELCC Study Update on August 14, 2013 indicating that the  
7 results were being revised upward, although the revised study is not yet final. Xcel’s  
8 updated results are based on ELCC calculations using time-correlated data for 2008-  
9 2010. Xcel’s new ELCC results are as follows:

- 10 • **Fixed Arrays:** 49.8% - 57.0% of Maximum AC Output, or 42.33% -48.45% of  
11 the DC rating.
- 12 • **Tracking Arrays:** 56.6% -61.7% of Maximum AC Output or 48.11%-52.45% of  
13 the DC rating.<sup>6</sup>

14  
15 To correctly apply these updated ELCC results to Geronimo’s Solar Proposal, it is  
16 important to understand the differences between the solar photovoltaic (“PV”) design  
17 assumptions used in the ELCC Study Update and the specific design proposed by  
18 Geronimo. The updated ELCC Study Update results assume PV systems have an 85%  
19 DC to AC efficiency.<sup>7</sup> This efficiency rating is typical of residential PV systems  
20 designed with a DC to AC ratio of 1 kW of solar modules to 1 kW of inverter nameplate  
21 capacity. Geronimo, however, has proposed a 130 MW DC, 100 MW AC linear axis  
22 tracking system with a DC to AC ratio of 1.3 MW of solar modules to 1 MW of inverter  
23 nameplate capacity. This design difference is more typical of utility scale solar projects

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<sup>6</sup> *Id.*, at Slide 10.

<sup>7</sup> *Id.*, at Slide 4.

1 and was specifically included within the Solar Proposal to increase the reliability and  
2 accredited capacity of Geronimo's proposal.

3 Because of this important distinction between the design assumptions in Xcel's  
4 ELCC Study and the design proposed by Geronimo, Xcel's AC ELCC percentages  
5 cannot be accurately applied to Geronimo's 100 MW AC nameplate capacity to calculate  
6 accredited capacity. Instead, to accurately apply Xcel's updated ELCC results, one must  
7 apply Xcel's 48.11% - 52.45% DC results to Geronimo's 130 MW DC nameplate  
8 capacity. Doing so eliminates inaccuracies that would otherwise result because of the  
9 differences in efficiencies between the ELCC Study assumptions and the specific design  
10 of the Solar Proposal.

11 As discussed in my opening testimony, the MISO AC capacity rating of this  
12 system is 71 MW. According to Xcel's updated ELCC results, a 130 MW DC tracking  
13 system would have an AC accredited capacity of 62.5 - 68.19 MW (130 MW DC times  
14 48.11% - 52.45%). The upper end of this range is only 4% below the MISO-accredited  
15 value of 71 MW, even though the two valuation approaches use different methodologies.

16 **Q: Please explain why you state that even Xcel's completed ELCC Study will not be**  
17 **used to determine the accredited capacity of Geronimo's Solar Proposal.**

18 A: As I described in my Direct Testimony, many regional transmission operators, including  
19 MISO, currently use the capacity factor method instead of an ELCC study to determine  
20 accredited capacity for intermittent resources. According to responses to Geronimo's  
21 information requests, neither the Department nor Xcel is aware of any current plans by

1 MISO to change this approach or to rely on Xcel’s ELCC Study, whenever it is final.<sup>8</sup>  
2 The MISO footprint, of course, is considerably larger than Xcel’s Minnesota service  
3 territory and extends from Manitoba to Louisiana for reliability coordination. It would be  
4 my expectation that MISO would want to evaluate the capacity value of solar across its  
5 entire footprint and that MISO is unlikely to rely on a single utility’s ELCC study.

6 **Q: On p. 20 of Department Witness Dr. Stephen Rakow’s Direct Testimony, Dr. Rakow**  
7 **also states that he modeled the Solar Energy Standard (“SES”) at 72% and 50%.**  
8 **Did you investigate the source of Dr. Rakow’s accredited capacity assumptions?**

9 A: Yes. Through information requests, Geronimo asked the Department to provide a  
10 reference to its 50% accredited capacity assumption.<sup>9</sup>

11 **Q: What did you discover in reviewing the Department’s response?**

12 A: The Department also relied on Xcel’s May 1, 2013 ELCC Study as the basis for assuming  
13 a 50% accredited capacity for the solar it modeled to meet the SES.<sup>10</sup>

14 **Q: Do you believe the Department erred in relying on the May 1, 2013 ELCC Study as**  
15 **the basis for its modeling?**

16 A: As I noted above, the May 1<sup>st</sup> ELCC Study was preliminary and inaccurate. Based on  
17 how the Department used these figures in its analysis, it appears to me, however, that the  
18 Department used two sets of assumptions to provide a range or sensitivity for the  
19 accredited capacity of all solar added to meet the SES, not as a commentary on or an  
20 evaluation of Geronimo’s specific proposal. Given that it is unclear at this time what will  
21 be the overall composition of the solar technologies used to meet Minnesota’s Solar

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<sup>8</sup> Geronimo IR No. 3 to DOC, Response attached as Schedule RTB-4 (Beach Rebuttal) and Geronimo IR No. 5 to Xcel, Response attached as Schedule RTB-3 (Beach Rebuttal).

<sup>9</sup> Geronimo IR No. 4 to DOC, Response attached as Schedule RTB-5 (Beach Rebuttal).

<sup>10</sup> *Id.*

1 Energy Standard, it is reasonable to run such sensitivities. If more systems are small,  
2 fixed, roof-top units or larger fixed systems (as compared to larger tracker systems), it is  
3 reasonable to assume that the average accredited capacity for all solar added to meet the  
4 SES will be lower than 70 percent. However, if more of the SES is satisfied using  
5 tracking systems like those proposed by Geronimo, it is reasonable to assume the higher  
6 accredited capacity. I raise this issue here to again draw the distinction that not all solar  
7 technology is the same and that Dr. Rakow's use of a range of potential accredited  
8 capacity should not be interpreted to indicate that Geronimo has miscalculated its  
9 accredited capacity or that the accredited capacity for the Solar Proposal is likely to  
10 change after Xcel releases its completed ELCC Study.

### 11 **III. ADDITIONAL VALUES OF SOLAR**

12 **Q: Geronimo Witness Elizabeth Engelking's Rebuttal Testimony discusses critiques of**  
13 **the Strategist model results and how there are additional, recognized, and**  
14 **quantifiable values of solar that should be similarly considered. What additional**  
15 **values of solar do you believe should be considered when comparing the Present**  
16 **Value Societal Costs ("PVSC") of Geronimo's Solar Proposal with other bid**  
17 **proposals in this docket?**

18 **A:** Geronimo's proposal will produce additional benefits beyond the avoided energy,  
19 generating capacity, and emission costs calculated in the Strategist model. These  
20 additional benefits include avoided transmission line losses, avoided system peak  
21 capacity losses, reduced transmission capacity costs, and avoided costs for solar  
22 renewable energy credits ("SREC"). I will discuss the first three of these below;



1 Geronimo’s witness Ms. Engelking will discuss SREC values and then summarize the  
2 additional ratepayer value that should be attributed to Geronimo’s proposal.

3 **Q: Please describe how the Solar Proposal results in reduced transmission line losses.**

4 A: By distributing its solar facilities so that each is in close proximity to a load center,  
5 Geronimo will displace energy that would otherwise be supplied by more distant  
6 generators, thereby reducing losses. Geronimo anticipates that the Project, as a  
7 distributed energy portfolio with distribution-level interconnections, will reduce losses by  
8 approximately 4% as compared to a central station generation facility interconnected at  
9 the transmission level.<sup>11</sup> Xcel’s witness Mr. Wishart also acknowledges that Geronimo’s  
10 project will result in line loss savings that “are likely to be less than 7%” and that at the  
11 7% level these savings would reduce the PVSC of Geronimo’s project by about \$10  
12 million.<sup>12</sup> Using Geronimo’s estimated 4% transmission losses and its bundled pricing  
13 proposal, Geronimo calculated a reduction in the PVSC of approximately \$9 million.  
14 These additional savings were not considered in the Strategist modeling of Geronimo’s  
15 project.<sup>13</sup>

16 **Q: Please describe how the Solar Proposal results in avoided system peak capacity**  
17 **losses.**

18 A: As just discussed, because the Geronimo units will be located on the distribution system,  
19 close to loads, they will avoid transmission line losses. From a capacity perspective, the  
20 Geronimo projects also will avoid the generating capacity needed to supply these avoided  
21 transmission line losses. These additional capacity savings are equal to the avoided

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<sup>11</sup> See Geronimo Energy’s Distributed Solar Energy Proposal, *In the Matter of the Petition of Northern States Power Company to Initiate a Competitive Resource Acquisition Process*, p. 31 (Docket No. E002/CN-12-1240).

<sup>12</sup> Xcel Witness Steven W. Wishart’s Direct Testimony, at 35.

<sup>13</sup> *Id.*

1 transmission line losses at the time of the system peak. These system peak capacity  
2 losses are certainly greater than 4%, because line losses increase significantly during  
3 peak periods when the system is heavily loaded.

4 **Q: Please describe how the Solar Proposal results in avoided transmission capacity**  
5 **costs.**

6 A: Power from Geronimo's solar facilities will be supplied directly to distribution  
7 substations. The capacity of the solar facilities is intended to be less than 20% of the  
8 peak demand at any substation; as a result, the power is highly likely to be consumed by  
9 the local distribution-level loads which each substation serves. As discussed in detail in  
10 Geronimo Witness Glen Skarbakka's Direct Testimony, Geronimo is selecting its sites  
11 and interconnection locations to minimize the impacts of its facilities on Xcel's  
12 transmission system. The Geronimo facilities will reduce the peak loadings on the Xcel  
13 transmission system, make more existing transmission capacity available to meet future  
14 load growth, and allow Xcel to avoid future capacity-related costs to expand its  
15 transmission system. Geronimo's distributed facilities will have this impact because they  
16 are interconnected at the distribution level, will be sited near loads that are much larger  
17 than their individual outputs, and are widely distributed across the Xcel service territory.  
18 Avoided transmission capacity costs are one of the values of distributed solar generation  
19 that recent legislation has directed should be included in a Value of Solar tariff in  
20 Minnesota.<sup>14</sup>

21 **Q: Are you able to provide an estimate of the monetized value of these avoided**  
22 **transmission capacity costs?**

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<sup>14</sup> Minn. Stat. § 216B.164, subd. 10(f) (2013).

1 A: Yes. The simplest approach is to use the existing MISO rate for network integration  
2 service on the Xcel system, which is \$45,644 per MW per year.<sup>15</sup> Because Geronimo's  
3 numerous small facilities will be widely distributed across Xcel's service territory, it  
4 makes sense to use a broad measure of transmission costs such as the rate for network  
5 integration service. Although this is an average cost rate, and not a marginal cost for  
6 transmission capacity, it does capture the amount by which an existing transmission  
7 customer of Xcel could reduce its costs by reducing its peak demand on the Xcel system  
8 by 1 MW. For the 71 MW of capacity that Geronimo would contribute to meeting Xcel's  
9 peak demands, the avoided transmission capacity costs would be \$3.24 million per year.  
10 This was not captured in the Strategist runs and results in a PVSC adjustment of \$33  
11 million.

12 **Q: Were any of these additional values of solar included in Xcel's or the Department's**  
13 **comparative analysis of the bid proposals?**

14 A: No, they were not. However, I note that this is a straightforward version of the  
15 methodology for valuing the transmission capacity benefits of distributed solar that the  
16 Department's consultant, Clean Power Research, has recommended in the ongoing Value  
17 of Solar workshops in Minnesota.<sup>16</sup>

18 **Q: Are any of the competing generation projects likely to provide the same benefit as**  
19 **Geronimo's project, in terms of reducing transmission line losses and capacity costs,**  
20 **or providing system peak capacity loss savings?**

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<sup>15</sup> See 2013 MISO Rates for OATT Schedule 9 (Network Integration Service) for Northern States Power (NSP Companies), at [http://www.oasis.oati.com/woa/docs/MISO/MISOdocs/Historical\\_Rate.html](http://www.oasis.oati.com/woa/docs/MISO/MISOdocs/Historical_Rate.html) .

<sup>16</sup> See Slide 46 of Clean Power Research's October 1, 2013 presentation, at [http://mn.gov/commerce/energy/images/MN-VOS-workshop\\_130916\\_v3.pdf](http://mn.gov/commerce/energy/images/MN-VOS-workshop_130916_v3.pdf) .

1 A: That is unlikely. To my knowledge, the other generation projects would be  
2 interconnected at the transmission level, and thus Xcel would make substantial use of  
3 transmission capacity to deliver their power. As a result, they will not avoid transmission  
4 capacity costs. Whether they provide transmission loss savings, or require Xcel to incur  
5 additional losses, would depend on their specific location on the grid and would require a  
6 site-specific loss study.

7 **Q: How would you recommend the ALJ and Commission consider these values when**  
8 **evaluating the various proposals?**

9 A: Geronimo's witness Ms. Engelking summarizes the additional ratepayer value that should  
10 be attributed to Geronimo's proposal.

11 **IV. CONCLUSION**

12 **Q: Does this conclude your rebuttal testimony?**

13 A: Yes, it does.

- Non Public Document – Contains Trade Secret Data**  
 **Public Document – Trade Secret Data Excised**  
 **Public Document**

Xcel Energy

Docket No.: E002/CN-12-1240

Response To: Geronimo Information Request No. 3

Requestor: Christina K. Brusven

Date Received: October 1, 2013

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Question:

Reference: Wishart Direct, p.18, ln 13-15:

Please provide copies of the Company's recent studies indicating "accredited capacity for this type of solar PV installation is likely to be in the range of 50 MW to 60 MW."

Response:

On May 1, 2013, the Company filed the Solar Effective Load Carrying Capability (ELCC) Study with the Minnesota Public Utilities Commission (Docket No. E002/CI-13-315). We include a copy of this study as Attachment A to this response

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Preparer: Mary Morrison

Title: Resource Planning Analyst II

Department: Resource Planning and Bidding

Telephone: 612-330-5862

Date: October 9, 2013



# Solar Stakeholder Workshop

**August 14, 2013**

# Solar ELCC Study Update

**August 14, 2013**



# Solar ELCC Analysis Update

- **Review of Initial Study Results**
- **Additional Solar Shape Development**
- **Average Peak Coincident PV Generation**
- **PROSYM ELCC Schedule**



# Review of May 1<sup>st</sup> Results

	ELCC Relative to Maximum AC Output	ELCC Relative to Maximum DC Output*
Fixed Panel PV	42.9%	36.5%
1-Axis Tracking PV	48.1%	40.9%

\* Assumes 85% DC to AC Efficiency

- **PVWatts Typical Meteorological Year (TMY)**
  - **Fixed Panel 45% Tilt 180deg Azimuth + 1 Axis Tracking**
  - **MSP/St Paul Airport**
- 

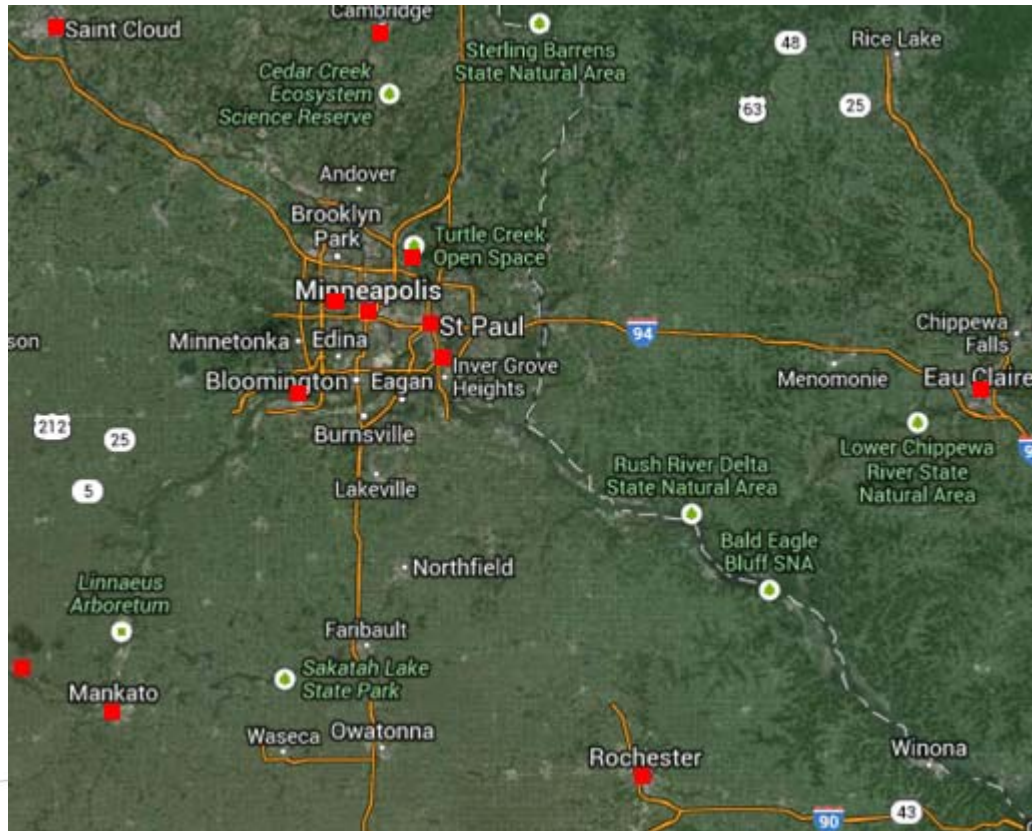
# Additional Solar Shape Development

- **National Solar Radiation Database (NSRD)**
  - **Hourly Solar Radiation and Weather Data for 1,454 Locations**
- **Solar Advisor Model**
  - **PV System Performance Simulator**
  - **Option to use NSRD data for custom PV shape development**
  - Global Horizontal Irradiance, Direct Normal Irradiance, Diffuse Horizontal Irradiance, Temperature, Dew-point, Relative humidity Pressure, Wind Speed, Albedo - *Ratio of reflected solar radiation to global horizontal radiation.*

# Additional Solar Shape Development

- **Years - 2008, 2009, 2010**
  - **Load & PV Shapes**
  
- **PV Systems**
  - **10% Tilt, 180deg Azimuth**
  - **30% Tilt, 180deg Azimuth**
  - **45% Tilt, 180deg Azimuth**
  - **30% Tilt, 200deg Azimuth**
  - **1-Axis Tracking, 180deg Azimuth**

# Additional Solar Shape Development



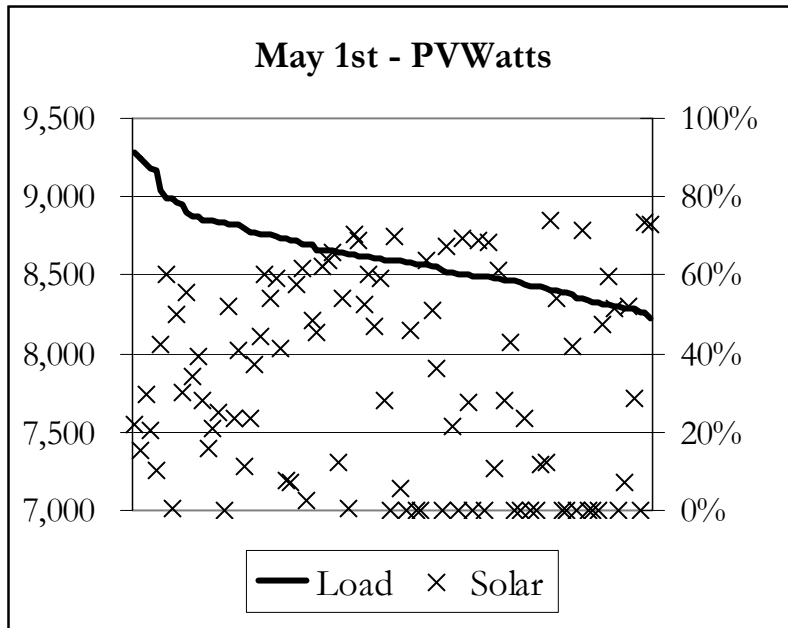
- Minneapolis
- St. Paul
- Eden Prairie
- South St. Paul
- St, Cloud
- Mankato
- Blaine
- Crystal
- New Ulm
- Rochester
- Cambridge
- Eau Claire

# PVWatts vs NSRD & SAM

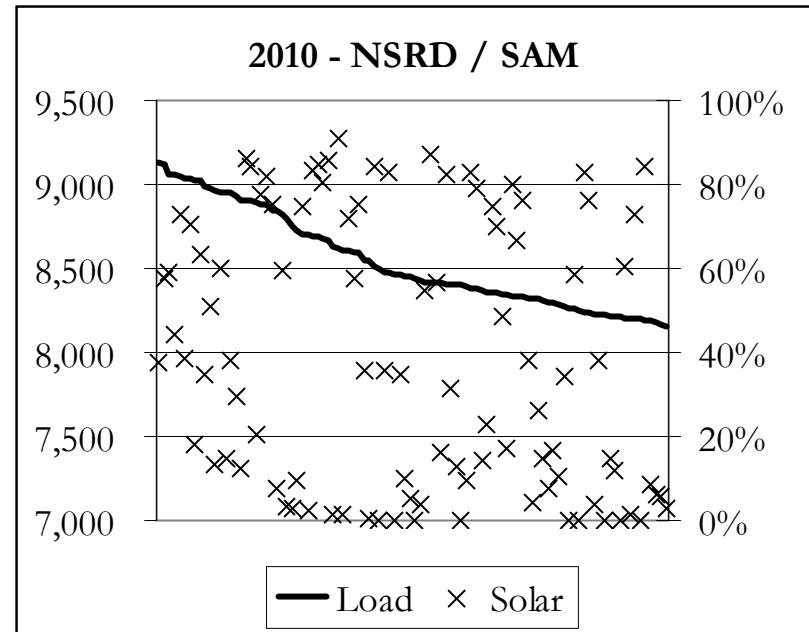
	Annual Capacity Factor*	July Peak Generation*
<b>PV Watts</b>		
45% - 180deg	15.7%	76%
1-Axis - 180deg	19.9%	78%
<b>NSRD &amp; SAM</b>		
10% - 180deg	14.3% - 14.5%	90%-91%
30% - 180deg	15.8% - 16.2%	93%-94%
45% - 180deg	15.9% - 16.4%	89%-91%
30% - 200deg	15.6% - 16.0%	92%-93%
1-Axis - 180deg	17.9% - 18.7%	89%-92%

\* Relative to maximum AC rating

# Load & Solar Coincidence



Average solar generation during 100 peak hours = 32%



Average solar generation during 100 peak hours = 39%

# APPROXIMATE ELCC Update

## ELCC Relative to Maximum AC Output

### May 1st - PV Watts

45% - 180deg  
 1-Axis 180deg

42.9%
48.1%

### NSRD / SAM

tilt-10 / az 180  
 tilt-30 / az 180  
 tilt-45 / az 180  
 tilt-30 / az 200  
 1-Axis 180deg

	2008	2009	2010
tilt-10 / az 180	52.6%	54.0%	50.6%
tilt-30 / az 180	52.5%	53.8%	51.4%
tilt-45 / az 180	49.8%	51.0%	49.5%
tilt-30 / az 200	56.9%	57.0%	55.1%
1-Axis 180deg	61.7%	60.9%	56.6%

\* ELCC Approximation based on peak hour generation. Final PROSYM simulations to be conducted.

# ELCC Next Steps

- **Development of Geographically Diverse Solar Shape**
- **PROSYM ELCC Simulations**
- **ELCC Report Update**



- Non Public Document – Contains Trade Secret Data**  
 **Public Document – Trade Secret Data Excised**  
 **Public Document**

Xcel Energy

Docket No.: E002/CN-12-1240

Response To: Geronimo Information Request No. 5

Requestor: Christina K. Brusven

Date Received: October 1, 2013

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Question:

Reference: Wishart Direct, p. 22, ln. 21-23.

“Pending updated results from our effective load carrying capability (ELCC) study, we are assuming an accreditation factor of 42% (36% relative to the DC rating).”

- a) Please provide the date Xcel’s ELCC Study is expected to be complete.
- b) Please list the solar technologies and provide the data analyzed in Xcel’s ELCC study.
- c) Does Xcel have any knowledge that its completed ELCC study will be used by MISO to assign accredited capacity to solar projects? If so, please provide a reference or citation to any public announcements from MISO indicating such a change will occur.

Response:

- a) We have committed to filing an update to our May 1, 2013 ELCC Study (Docket No. E002/CI-13-315) by November 1, 2013.
- b) The data studied included both fixed and tracking installations. The May 1<sup>st</sup> study included the data used in the analysis. Please see Attachment A to this response.
- c) No, we do not expect that MISO will use the results of our ELCC study to assign accredited capacity for solar projects. However, we do expect MISO to adopt an ELCC methodology in the future. This expectation is based on the fact that MISO began accrediting wind resources using the same peak hour averaging methodology that is currently applied to solar. As the amount of wind in the MISO footprint expanded, they adopted the ELCC methodology for wind.

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Preparer: Steve Wishart  
Title: Director – Resource Planning & Bidding  
Department: Resource Planning & Bidding  
Telephone: 612-330-6128  
Date: October 9, 2013

[Geronimo Note: Data provided with Xcel's Response was excluded from Schedule RTB-3 (Beach Rebuttal) because it was voluminous and not cited by Mr. Beach.]

**State of Minnesota**  
**DEPARTMENT OF COMMERCE**  
**DIVISION OF ENERGY RESOURCES**  
  
**Utility Information Request Response**

Docket Number: E002/CN-12-1240

Date Request Received: October 1, 2013

Requested By: Geronimo Energy

Date of Response: October 3, 2013

Response submitted by: Steve Rakow

Request No.	
3	<p>Reference: Rakow Direct, p. 12, ln 13-15:</p> <p>“This would allow the RFP to be issued after the Effective Load Carrying Capability (ELCC) study is completed, which would give better information regarding the production of solar power compared to Xcel’s load.”</p> <p><u>Question</u></p> <p>Does the Department have any knowledge that Xcel’s completed ELCC study will be used by MISO to assign accredited capacity to solar projects? If so, please provide a reference or citation to any announcements from MISO indicating such a change will occur.</p> <p><b><u>DOC Response:</u></b></p> <p>No.</p>

**State of Minnesota**  
**DEPARTMENT OF COMMERCE**  
**DIVISION OF ENERGY RESOURCES**

**Utility Information Request Response**

Docket Number: E002/CN-12-1240

Date Request Received: October 1, 2013

Requested By: Geronimo Energy

Date of Response: October 3, 2013

Response submitted by: Steve Rakow

Request No.	
4	<p>Reference: Rakow Direct, p. 20, ln. 15-16:</p> <p>“The two different solar constructs relate to a 72 percent and a 50 percent solar accreditation by MISO.”</p> <p><u>Question:</u></p> <p>Please provide a reference or the Department’s reasoning for using a solar construct that assumes a 50 percent solar accreditation.</p> <p><b><u>DOC Response:</u></b></p> <p>See Attachment A for a reference. Specifically, the data on page 5 of 26 of Attachment A indicate that a 45 to 50 percent accreditation factor would be a reasonable lower bound.</p>



414 Nicollet Mall  
Minneapolis, MN 55401

May 1, 2013

—Via Electronic Filing—

Burl W. Haar  
Executive Secretary  
Minnesota Public Utilities Commission  
121 7<sup>th</sup> Place East, Suite 350  
St. Paul, MN 55101

RE: SOLAR EFFECTIVE LOAD CARRYING CAPABILITY (ELCC) STUDY  
DOCKET NO. E002/CI-13-315

Dear Dr. Haar:

Northern States Power Company, doing business as Xcel Energy, submits the attached preliminary Effective Load Carrying Capability (ELCC) study as proposed in our January 18, 2013 Reply Comments in Docket No. E002/GR-10-971 and ordered by the Minnesota Public Utilities Commission at their April 25, 2013 meeting.

Because all customers pay for the costs of power obtained from solar resources, it is important to closely align the price paid for solar power with the value provided by solar resources. The attached study analyzes the contribution of distributed solar electric generation to electric system reliability and the capacity value of solar on the NSP System. The Company also estimated accredited capacity for large solar systems using the methodology for intermittent resources prescribed by the Midwest Independent System Operator (MISO). We believe ELCC analysis and the MISO accreditation methodology are valuable tools to establish a sound basis for the value of solar that could be recognized in rates, regardless of the specific rate mechanism. For example, the analysis can be used to inform an appropriate solar capacity credit in the Standby Service Tariff or the buy rate under a Buy-all/Sell-all framework.

The Company will organize a meeting to review and discuss the preliminary study with interested parties, including the modeling assumptions and methodologies, and modify the analysis as necessary in response to parties' feedback. As ordered by the Commission, we will submit a solar rate proposal on October 1, 2013 that reflects the final analysis and any regulatory or policy changes that occur as part of

May 1, 2013

the current legislative session. We will provide an update on July 1, 2013 that reports on our progress in working with stakeholders on the rate proposal.

We have electronically filed this document with the Minnesota Public Utilities Commission, and copies have been served on the parties on the attached service list.

Please contact me at amy.a.liberkowski@xcelenergy.com or 612-330-6613 if you have any questions regarding this filing.

Sincerely,

/s/

AMY LIBERKOWSKI  
MANAGER  
REGULATORY ANALYSIS

Enclosures  
c: Service Lists

**Effective Load Carrying Capability (ELCC) Study  
for Solar Generation Resources**

**Preliminary Results**

Xcel Energy  
Docket No. E002/CI-13-315

May 1, 2013

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## I. Executive Summary

The goal of studying the value of solar resources in meeting peak electric demand is to develop a rate that appropriately reflects the value provided by solar resources, while protecting the interests of other customers who ultimately pay the costs of electricity purchased from these resources.

The analysis presented in this study expands on the work done in the Company's 2012 Solar Load Profile Study. Using a detailed simulation model, the Company calculated the effective load carrying capability (ELCC) of solar PV systems on the NSP System, which measures the contribution of solar to meeting peak electric demand. The Company also estimated accredited capacity using the methodology for intermittent resources prescribed in the Resource Adequacy Business Practices Manual developed by the Midwest Independent System Operator (MISO). The MISO methodology offers some advantages over the ELCC method, since it has received a thorough review process and can be easily replicated for individual projects.

The ELCC simulations used typical meteorological year (TMY) solar shapes that correlate well with the TMY load shapes used in the Company's simulation model. The MISO methodology was applied to the TMY data, as well as the actual data from three customer sites as presented in the 2012 Solar Load Profile Study. The analysis results show that, due to its variable nature, solar contributes less than its maximum rating to system reliability at peak periods.

**ELCC & MISO Accreditation Summary Results\***

<b>Typical Meteorological Year</b>	<b>MISO Accreditation</b>	<b>ELCC</b>	<b>Average</b>
TMY – Fixed Panel	45.4%	42.9%	44.2%
TMY – 1-Axis Tracking	52.3%	48.1%	50.2%

<b>Customer Sites</b>	<b>MISO Accreditation</b>
Customer Site 1 – Fixed Panel	60.7%
Customer Site 2 – Fixed Panel	58.6%
Customer Site 3 – 1-Axis Tracking	57.2%

\* Percent of AC nameplate value

It is important to note that the data used in this analysis is limited. Currently, the NSP System has approximately 10 MW of solar resources in its entire footprint and MISO has yet to accredit any large solar installations.

## II. Background

The Company currently has five customers with grid-connected solar PV systems that exceed the 60 kW<sub>AC</sub> threshold requiring service under our Standby Service Tariff. The first system came online in April 2010. The most recent system came online in March 2013. Effective June 1, 2013, customers on the Standby Service Tariff will receive an interim solar capacity credit of \$5.15 per kW per month.<sup>1</sup> This amount is halfway between the midpoint of the range identified by the Department and the Solar Rate Reform Group, \$8.35, and the value suggested by the Company in its 2012 Solar Load Profile Study, \$2.00. As ordered by the Commission, the Company will submit a new solar rate proposal on October 1, 2013 with a target implementation date of January 1, 2014.

The Company completed a solar load profile study in response to the Settlement Agreement in the Company's 2011 Test Year general electric rate case (Docket No. E002/GR-10-971). Specifically, the Settlement Agreement states:

**F.2. Large Solar Facilities.** The Chamber proposed development of a new DG Solar rate that: a) would not have standby requirements; b) would not have demand charge penalties; and c) would reflect the Special MISO Mod E accrediting rating for solar installations. At this time, the Company lacks the information needed to determine the reasonableness of the Chamber's request. *The Company agrees to study the load profile of larger Solar facilities to determine the applicability of a solar facility's unique load characteristics to the standby and supplemental rate tariff and share those results with the Chamber by August 15, 2012.* (Italics added)

The Commission's May 14, 2012 FINDINGS OF FACT, CONCLUSIONS AND ORDER in the same docket required the study results to be filed with the Commission and shared with the Department of Commerce. The Company complied with the requirements, sharing the results with the Chamber on August 15, 2012 and filing public and non-public versions of the study on August 24, 2012. On September 14, 2012, the Company re-filed the study with the previously redacted information made public.

The 2012 Solar Load Profile Study provided an analysis of the production profiles of PV facilities greater than 60 kW<sub>AC</sub> located at three customer sites using metering data. The customer-based analysis was also applied to solar data

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<sup>1</sup> As ordered by the Commission at the April 25, 2013 hearing in Docket Nos. E002/GR-10-971 and E002/M-10-1278.

sets based on a typical meteorological year<sup>2</sup> (TMY) for locations at the Minneapolis-St. Paul International Airport (MSP) and the St. Cloud Regional Airport (StC). The results showed that the average solar generation during the summer peak demand hours of 1 p.m. to 7 p.m. ranged from 37% to 50% of maximum rated AC output.<sup>3</sup> Table 1 provides the availability factor results from the Solar Load Profile Study.

**Table 1: Solar Facility Availability Factor Summary**

1 p.m. - 7 p.m. On-Peak							
Customer Sites				Modeled Sites			
<i>Tracking:</i>	Fixed	Fixed	1-Axis	Fixed	Fixed	1-Axis	1-Axis
Site	1	2	3	MSP	StC	MSP	StC
Summer	47%	43%	46%	37%	37%	50%	50%
Winter	25%	27%	24%	23%	23%	28%	29%
Annual	32%	33%	30%	25%	25%	33%	32%

\* Percent of AC nameplate value

The study concluded that solar contributes to meeting the Company’s peak demand, but the contribution is highly variable by time of day, month, and customer load requirement. Due to the limited data available, the Company advised that further analysis would be needed to support decision-making. The ELCC study provides the preliminary results of this additional analysis.

### III. Effective Load Carrying Capability (ELCC) of Solar

This preliminary analysis calculates the effective load carrying capability (ELCC) of solar PV systems on the NSP System, which measures the contribution of solar to meeting peak electric demand. The results should be regarded as generalizations, as the actual contribution of any one specific PV installation will depend on site location, panel orientation, and type of equipment used. As discussed below, the Company used a detailed simulation model of system reliability to calculate the ELCC based on TMY solar patterns for the Minneapolis airport location from the National Renewable Energy Laboratory’s (NREL) PVWatts<sup>4</sup> database.

<sup>2</sup> A typical meteorological year is an 8,760 hourly pattern that represents typical atmospheric conditions at a specific location.

<sup>3</sup> The summer peak demand period is defined as 1 p.m. to 7 p.m. during the months of June through September.

<sup>4</sup> <http://www.nrel.gov/rredc/pvwatts/>

## A. Methodology

The calculation of ELCC incorporates the use of a measure of electric system reliability called loss of load expectation (LOLE). LOLE is calculated by taking the average of the hourly loss of load probabilities (LOLP) over an entire year. LOLPs are in turn calculated using computer models that simulate a utility's hourly loads, generation capacity, and forced outage rates. For this study, the Company set its reliability target as an LOLE of one day in 10 years (or 2.4 hours per year), which is an industry standard typically used when evaluating system reliability.

The ELCC attributed to solar generation can be calculated by analyzing two generation portfolios: one with incremental solar generation and another with an incremental, generic capacity resource such as a gas-fired combustion turbine. Once the system without either incremental solar generation profile or the incremental generic capacity resource has obtained the target LOLE of one day in 10 years, the incremental solar resource is added to the system and the resulting LOLE becomes the target for the incremental, generic capacity resource profile. The total capacity of the incremental, generic capacity resource portfolio is adjusted until the annual average of the portfolio's hourly LOLPs is equal to the target LOLE value obtained with the solar generation profile. Then, the ELCC of the solar generation is obtained by dividing the incremental generic capacity resource  $MW_{AC}$  by the incremental solar  $MW_{AC}$ . For example, an ELCC measure of 45% indicates that 45 MW of combustion turbine capacity would supply the same peak capacity requirements as 100 MW of installed solar capacity. It can be considered the percent of a PV system's maximum AC output that is available, on average, to meet system peak demand.

The Company conducted this ELCC analysis utilizing a ProSym<sup>5</sup> production cost simulation model. ProSym uses a TMY pattern to represent the hourly energy demand from our customers. As such, it was appropriate to use solar patterns that were also based on a TMY. If actual solar generation patterns from metered installations had been used, there would potentially have been a misalignment between solar generation and customer demand, which could have skewed the result of the LOLE calculation. Additionally, at this time, the number of actual customer sites and duration of metering data is insufficient to develop a representative sample.

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<sup>5</sup> ProSym is a Ventyx product used in resource planning.

ProSym was run using two different TMY shapes from NREL’s PVWatts<sup>6</sup> database. One was based on a fixed panel installation with a 45 degree tilt and a 180 degree azimuth (due south); the other was a single-axis tracking design with the same orientation that has the ability to track the sun as it moves across the sky. The orientations of these panels are typical for the Minnesota region, as they maximize the total annual capacity factor of solar arrays. As illustrated in Table 2, designing solar installations for maximum annual generation does not result in production at maximum capacity during the summer months when customer demand is highest. Instead, maximum output is achieved in February and March when the sun’s position in the sky most closely matches the 45 degree tilt that was assumed in the TMY solar shapes.

**Table 2: TMY Solar Shape Summary**

	Fixed Panel		1-Axis Tracking	
	Average Capacity Factor	Maximum Generation	Average Capacity Factor	Maximum Generation
Jan	14%	96%	17%	95%
Feb	17%	100%	20%	100%
Mar	17%	100%	20%	100%
Apr	16%	89%	21%	91%
May	19%	88%	25%	89%
Jun	19%	78%	25%	78%
Jul	18%	76%	26%	78%
Aug	17%	76%	23%	78%
Sep	17%	81%	21%	81%
Oct	15%	84%	18%	84%
Nov	10%	79%	11%	79%
Dec	10%	86%	12%	86%
Annual	16%	100%	20%	100%

The specific procedure used in ProSym to calculate the ELCC of solar is as follows:

- 1) Set up ProSym model for reliability run analyses and convert all scheduled maintenance days to maintenance rates.
- 2) Adjust the firm generic resource capacity in ProSym until the system’s LOLE is equal to one day in 10 years.
- 3) Add 100 MW<sub>AC</sub> solar profile to the NSP System and run ProSym to record the resulting (lower) LOLE.
- 4) Remove the 100 MW<sub>AC</sub> solar profile from ProSym and incrementally add small amounts of firm generic resource capacity (natural gas

<sup>6</sup> <http://www.nrel.gov/rredc/pvwatts/>

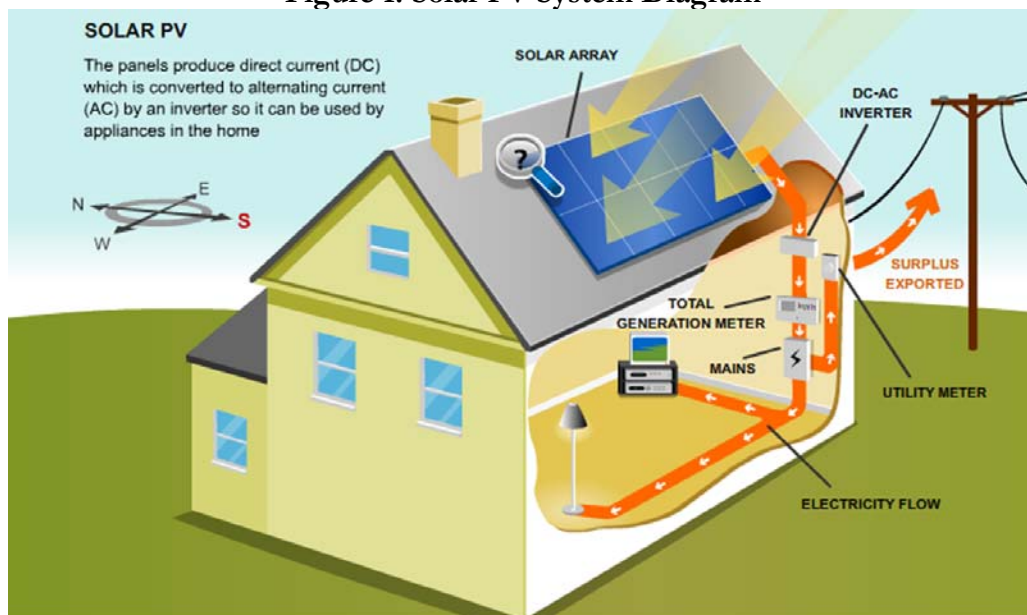
combustion turbine) until the LOLE returns to the lower LOLE observed in the previous step.

- 5) Calculate ELCC as  $(\text{Firm Resource Capacity}) / 100 \text{ MW}_{\text{AC Solar}}$

The analysis used 100 MW increments of solar because, after testing, it was determined that the actual 10 MW level of solar on the NSP System was too small to produce reliable model results. Because the ELCC of solar is approximately 50% of the maximum rating, the amount of firm capacity in the ProSym model using the actual 10 MW on our system was only about 5 MW. In the context of the 10,000 MW NSP System, such a small increment of firm capacity was essentially “lost in the noise” of the rest of the model simulations. Testing with 100 MW provided much more stable results, allowing the ELCC values to be generalized to the smaller MW levels currently on the system.

We present the results as both a percent of AC capacity and DC capacity. As shown in Figure 1 below, solar panels create DC electricity that is passed through an inverter for conversion to AC electricity that can be used by end users or exported to the distribution grid. Some electricity is lost through the conversion process. This analysis assumed an inverter efficiency rating of 85%, which means that the maximum generation capacity of the PV system is 15% less than the DC nameplate capacity.

**Figure 1: Solar PV System Diagram**



Accompanying this study on compact disk is a comprehensive data package to assist in stakeholder review. The data is contained in two spreadsheets. The

first spreadsheet titled “ELCC Data” contains the hourly inputs for load and solar profiles used in the analysis and the hourly LOLP results produced by ProSym. The second spreadsheet titled “MISO Method and Charts” provides the data and calculation for estimating the capacity credit values under the MISO methodology and the supporting data for the charts presented in the study. Attachment A provides an index to the data included in the spreadsheets.

## B. Results

ProSym modeling results indicated that fixed panel installations have an ELCC of 42.9%, while single-axis tracking systems have an ELCC of 48.1%. That is, 42.9% of the maximum AC rating of a fixed panel PV installation and 48.1% of the maximum AC rating of a single-axis tracking system can be counted as firm capacity that contributes to total system reliability. Assuming an inverter efficiency rating of 85%, the corresponding DC ratings would be 36.5% and 40.9% for fixed panel and single-axis tracking, respectively. As previously noted, these results are based on TMY patterns with a 45% tilt and a 180 degree azimuth. The actual ELCC of any specific solar installation will vary year to year depending on the amount of solar insolation received and the orientation of the panel. Table 3 summarizes the ELCC values for fixed panel and single-axis tracking PV installations.

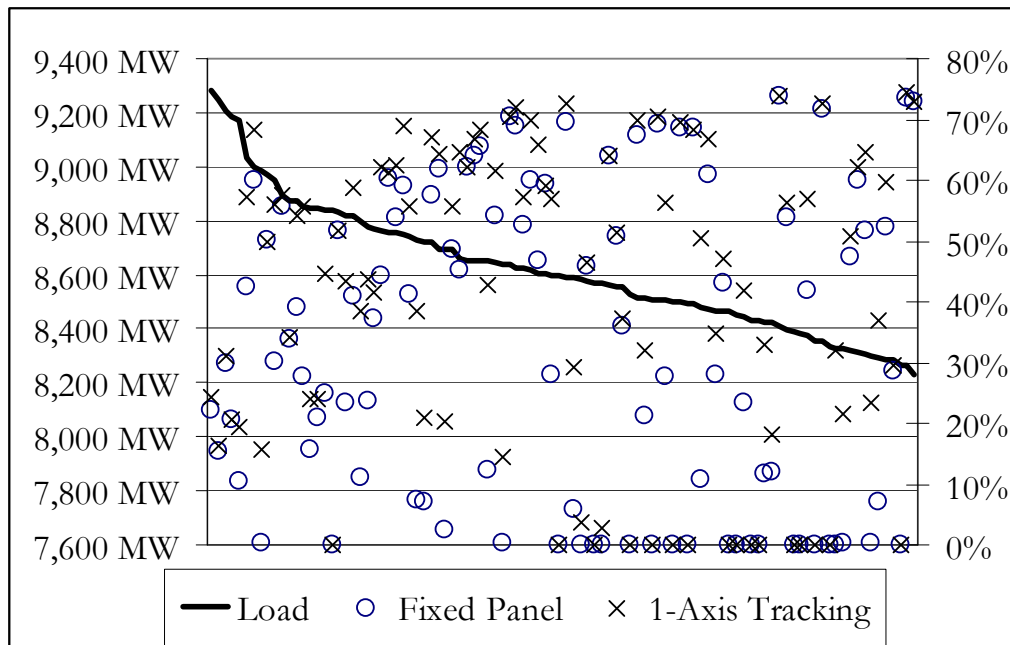
**Table 3: ELCC Results**

	<b>ELCC Relative to Maximum AC Output</b>	<b>ELCC Relative to Maximum DC Output*</b>
Fixed Panel PV	42.9%	36.5%
1-Axis Tracking PV	48.1%	40.9%

\* Assumes an inverter efficiency of 85%.

While calculation of solar’s ELCC involves summing its contribution to system reliability in every hour of the year, the greatest contribution occurs during periods of the highest customer demands. Figure 2 illustrates the 100 highest customer demand hours, as modeled in ProSym, and the solar generation in each of those hours based on the PVWatts TMY. The secondary y-axis on the right measures the solar generation as a percent of maximum AC capacity. These results are specific to this ELCC study. Analysis of data from a specific year and specific site may produce different results, including greater (or lesser) correlation between peak demand and solar output.

**Figure 2: Solar Generation During Highest 100 Demand Hours**

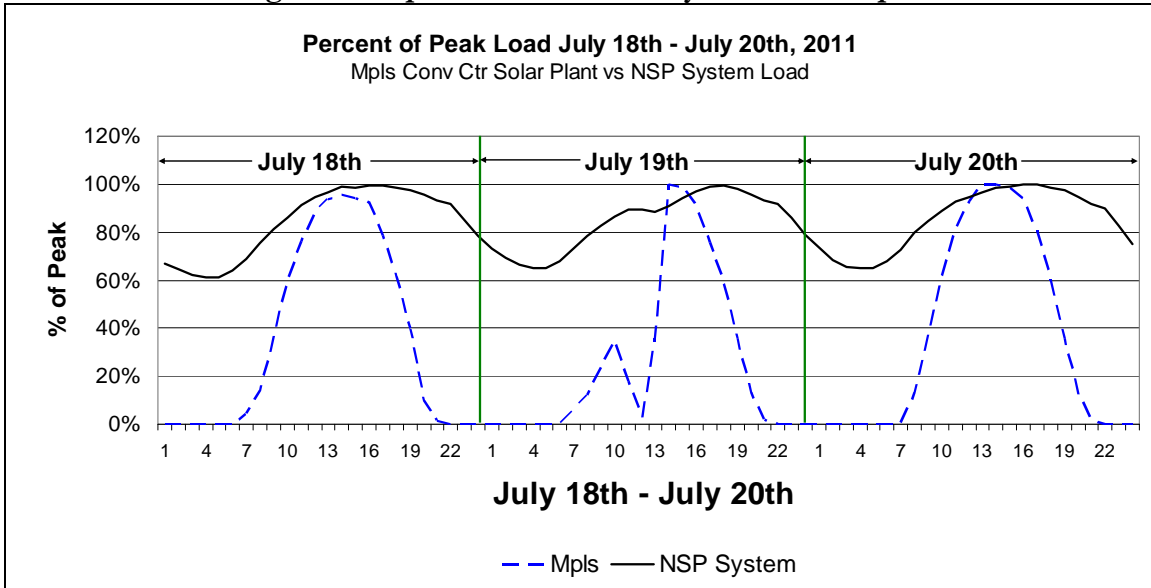


As shown above, during the 100 highest customer demand hours modeled in ProSym, fixed panel PV generates no energy in 18 hours, while single-axis tracking systems generate no energy in 14 hours. Inspection of the data reveals that these hours are between 6 p.m. and 10 p.m. in July and August. There are instances in the solar data where tracking systems generate power as late as 8 p.m. and fixed panel configurations generate as late as 7 p.m. However, these instances do not coincide with the highest customer demand hours.

Figure 2 also highlights the variability of solar's contribution to meeting peak demand. There could be several reasons why solar output is not more closely correlated with periods of high demand. For example, it is possible that during periods of peak demand there may be atmospheric interferences (clouds or haze) that limit peak generation from solar panels. Figure 3 illustrates the impact of a storm's disturbance of solar output using actual solar output and system load data over a period of three days in July 2011. The solar output as a percentage of peak drops significantly on July 19 from 10 a.m. to 2 p.m. (hours 10-14), as the cloud interference related to a storm passes between the sun and the PV installation. Since the ELCC is measurement of reliability, the possibility of this type of weather event explains a portion of the difference between the ELCC finding and peak output of the PV system over a period of time.

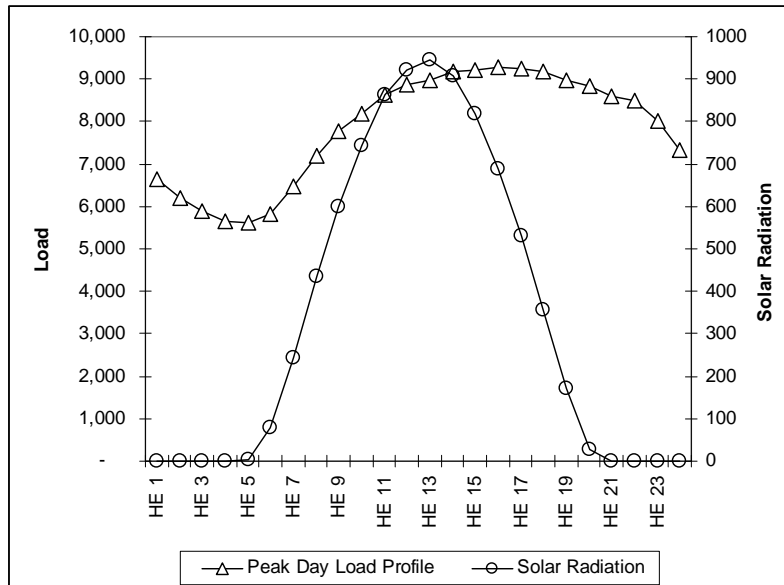


**Figure 3: Impact of Storm Activity on Solar Output**



Additionally, peak load hours tend to occur later in the day when solar radiation is not at its peak. Figure 4 illustrates the typical hourly load pattern for a peak demand summer day on the NSP System and corresponding measured solar radiation. A similar pattern is present in Figure 3.

**Figure 4: Peak Day Load Profile and Solar Radiation<sup>7</sup>**



<sup>7</sup> Solar radiation source: National Solar Radiation Database - [http://rredc.nrel.gov/solar/old\\_data/nsrdb/1991-2010/](http://rredc.nrel.gov/solar/old_data/nsrdb/1991-2010/)

### **C. Analysis Limitations**

The Company believes it has produced a sound analysis of the ELCC for solar generation. As with any model, however, there are limitations to our analysis. For example, it was not possible to perfectly align the solar patterns with the load shape used in ProSym. While both solar and load patterns represent typical meteorological years, the vintages are different. The PVWatts database used years ranging from 1963 to 1990 to develop the TMY for solar. The load shape in ProSym is a TMY developed using data from the years 1990 to 1996. Thus, the weather patterns represented in the solar shape are not identical to the patterns in the load shape; both represent typical or average weather patterns, but they are not identical. Due to limited data, it does not seem possible to either fit actual solar data to ProSym's current load TMY, nor is it possible to find hourly load data from 1963 to 1990 that would fit the TMY that is used by PVWatts. One recommendation for future improvement in the assessment of solar's contribution to system reliability is to develop new TMY patterns for solar and load. The Company welcomes suggestions on how to improve the fit of the data.

### **IV. MISO Accreditation of Intermittent Resources**

The Company also evaluated solar's contribution to peak demand using a methodology established by MISO. Any solar resource that connects directly to the transmission system and seeks to be accredited as a network resource must register with MISO and calculate a capacity credit. Currently, there are no large solar generation facilities that have received capacity credit in MISO.

The Resource Adequacy Business Practices Manual (BPM) specifies a methodology for establishing an accredited capacity value of non-wind intermittent generation. Section 4.2.2.3 of the BPM states:

All other Intermittent Generation and Dispatchable Intermittent Resources will have their annual UCAP value determined based on the 3 year historical average output of the resource for hours 1500-1700 EST for the most recent Summer months (June, July, and August).<sup>8</sup>

For systems that are new, upgraded or returning from extended outages, where data does not exist for some or all of the previous 36 months, MISO instructs applicants to submit all operating data for June, July, or August with a

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<sup>8</sup> <https://www.midwestiso.org/Library/BusinessPracticesManuals/Pages/BusinessPracticesManuals.aspx>

minimum of 30 consecutive days, in order to have their new or upgraded capacity registered with MISO.

The Company does not have three full years of hourly data that can be used to calculate the MISO UCAP value for solar. As a substitute, we applied the methodology to the single year of TMY data used in the ELCC analysis and the three sets of customer data presented in our 2012 Solar Load Profile Study. The results are summarized in Table 4.

**Table 4: Solar Accreditation – MISO Methodology**

	<b>MISO Accreditation Relative to Maximum AC Output</b>	<b>MISO Accreditation Relative to Maximum DC Output*</b>
<b>TMY – Fixed Panel</b>	45.4%	38.6%
<b>TMY – 1-Axis Tracking</b>	52.3%	44.5%
<b>Customer Site 1 – Fixed Panel</b>	60.7%	56.5%
<b>Customer Site 2 – Fixed Panel</b>	58.6%	49.8%
<b>Customer Site 3 – 1-Axis Tracking</b>	57.2%	51.0%

\* TMY values assume 85% inverter efficiency

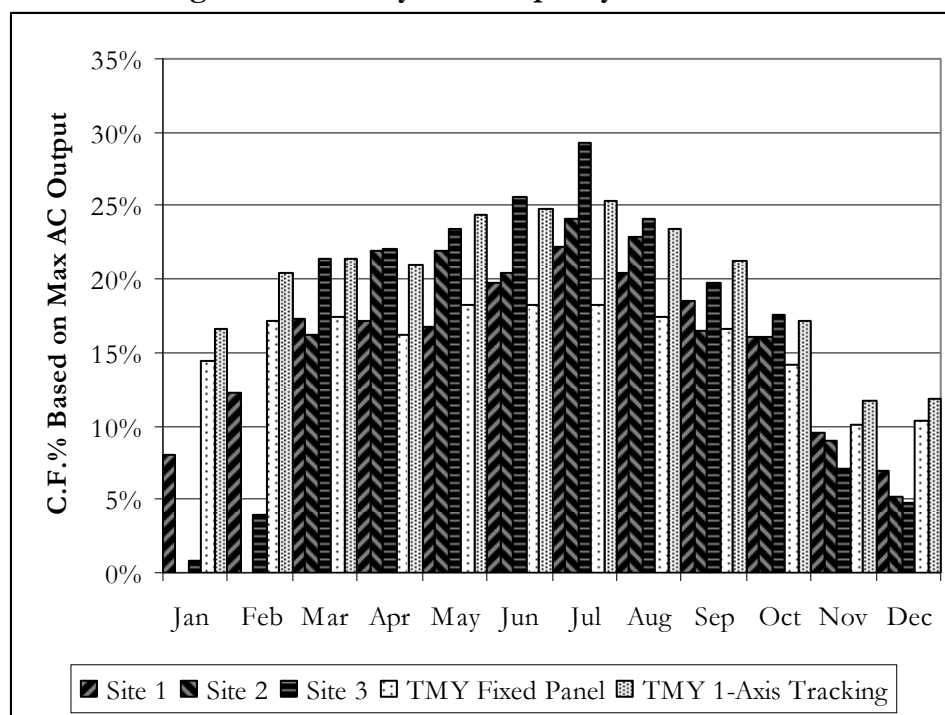
Using the MISO methodology, the accredited values for the customer sites is slightly higher than for the TMY data used in the ELCC analysis. It is possible that these sites have oriented their panels to capture more solar energy during peak periods, either by tilting panels to be flatter than the 45 degrees assumed in the TMY data or by pointing panels in a more westerly direction.

Figure 5 illustrates that the TMY shapes have more consistent year-round generation, while the generation at customer sites is more focused on the summer months.<sup>9</sup> Additionally, Attachment B provides charts of average generation by hour for June, July, and August for the customer sites and TMY shapes. These charts show that the generation in the TMY shapes is higher in the morning hours and lower in the afternoon in comparison to the customer data. This indicates that the azimuth of the customer sites might be oriented more towards the west than the due south orientation assumed by the TMY data. Without a larger sample of customer sites and a longer interval of metering data, it is not known if these customer site results are representative of the overall solar population or just particular to the three sample data set the Company was able to obtain.

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<sup>9</sup> The data for site 2 in January and February was unavailable.

**Figure 5: Monthly Solar Capacity Factor Values**



**V. Rate Implications**

A capacity credit should adequately reflect the contribution of solar to meeting peak demand, but not be excessive since all other customers pay for the credit. We used the results of the ELCC study and MISO methodology to estimate capacity credits by applying the solar capacity contribution percents to the generation (\$4.99 per kW) and transmission (\$2.52 per kW) cost components of the present average monthly demand charge. Although we have included transmission capacity cost credits in the table, transmission cost savings are not fully related to system peak loads and have not been clearly established. As shown in the table below, we estimate a generation capacity credit range of \$2.14 per kW to \$2.61 per kW, and if transmission capacity cost is included in the credit, the solar capacity credit range is \$3.22 per kW to \$3.93 per kW.

**Table 5: Estimated Solar Capacity Credits**

	Avg. Monthly Demand Charge	Fixed Panel		1-Axis	
		ELCC	MISO	ELCC	MISO
		42.9%	45.4%	48.1%	52.3%
Generation	\$4.99	\$2.14	\$2.26	\$2.40	\$2.61
Gen. + Trans.	\$7.51	\$3.22	\$3.41	\$3.61	\$3.93

The estimated solar capacity credits are derived from seasonal demand charges for firm service to maintain a consistent embedded cost basis for both rates and rate credits. The direct application of a solar capacity contribution percent to a current avoided cost could produce a credit that is inconsistent and out of proportion to the present rate that is credited.

## **VI. Conclusion**

The analysis presented in this preliminary study confirms that solar generation contributes to system reliability, but at far less than its maximum rating. Based on the TMY analysis and the ELCC and MISO methodologies, fixed panel PV contributes, on average, 44% of its maximum rating to meeting system peak. The single-axis tracking systems average 50% of maximum rating. The results also show that the ELCC methodology for calculating accredited capacity results in lower but generally consistent values compared to the method prescribed by MISO.

## **Index for Data Package**

### Attachment A.1 – ELCC Data.xls

Tab 1 – Solar & Load Inputs

Tab 2 – Hourly LOLP Results

Tab 3 – Figure 2 Data (Solar Generation During Highest 100 Demand Hours)

### Attachment A.2 – MISO Method & Charts.xls

Tab 1 – Figure 2 (Peak Day Load Profile and Solar Radiation)

Tab 2 – Average Solar Shapes (as presented in Attachment A)

Tab 3 – Figure 4 (Monthly Solar Capacity Factor Values)

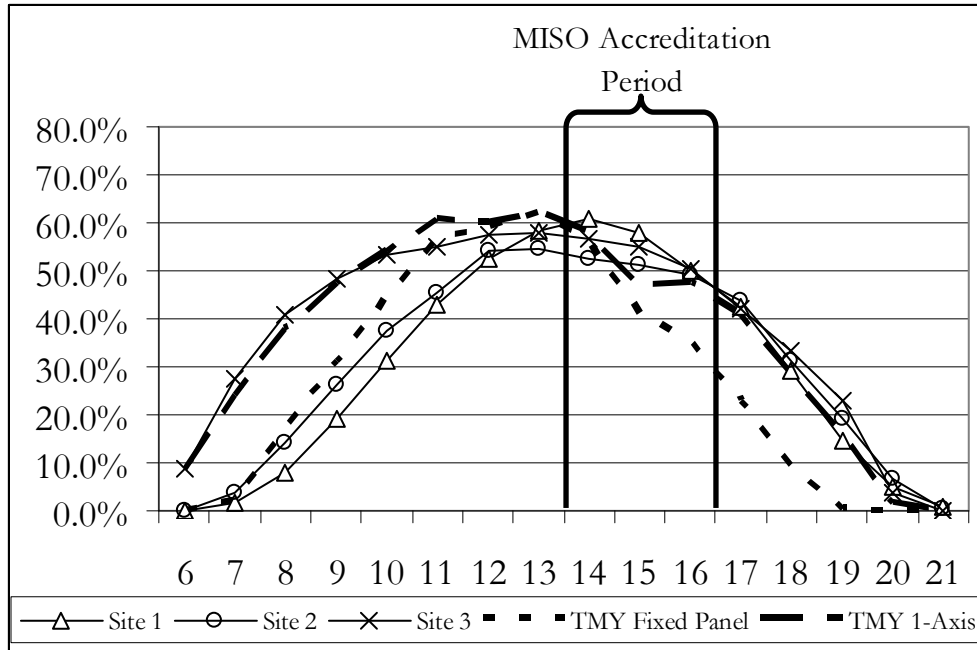
Tab 4 – Summary Data (Including MISO accreditation calculations)

Tab 5 – Site Data (Hourly data and summary calculations)

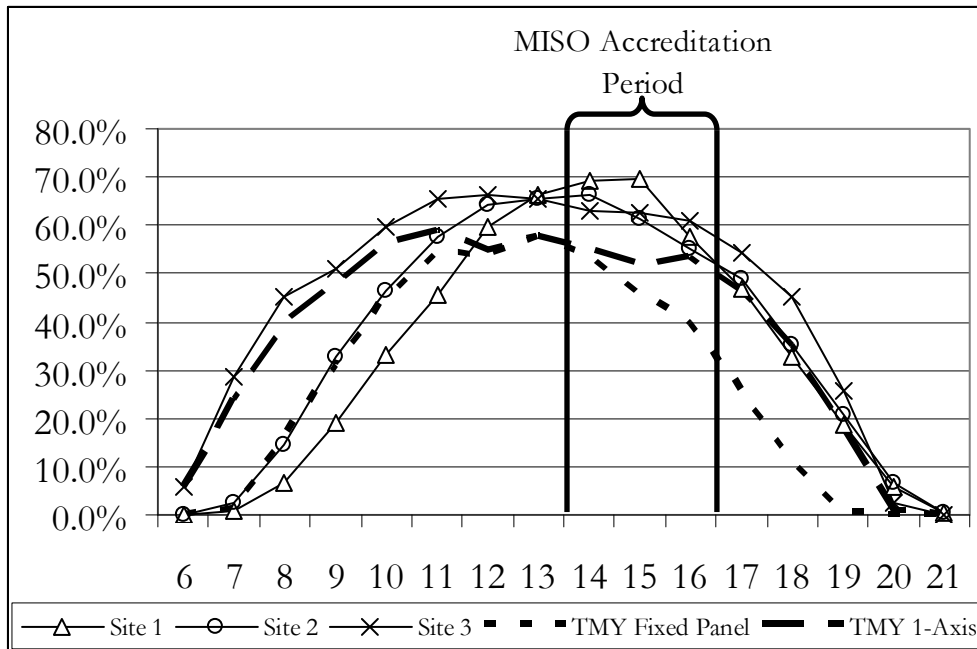
Tab 6 – TMY Data (Hourly data for TMY shapes)

### Average Generation by Hour for June, July, and August

#### Average Hourly Generation - June



#### Average Hourly Generation - July



### Average Hourly Generation - August

