MARQUETTE BOARD OF LIGHT & POWER
MBLP
Solar Renewables Valuation Study
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MBLP

Executive Summary – Solar Renewables Valuation Study

Introduction

This report was prepared to provide guidance on the valuation of solar renewable generation for MBLP. A number of customers are installing renewable generation to help off-set the cost of electricity and to produce power from carbon-free sources. The purpose of this report is to identify the value of solar for electricity produced by a solar generation resources. The study focused on three solar scenarios: (all are assumed to be fixed panel systems with no battery storage) However, provided that MBLP's current and planned generating portfolio (Marquette Energy Center) battery storage will not provide financial benefit to MBLP.

1. Residential roof top solar
2. Community Solar Project
3. Commercial roof top solar

To determine the value of renewables, UFS used a long-run marginal cost valuation considering a natural gas fired turbine generating unit as the next generation resource.

As a result of passage of the Public Utility Regulatory Act passed by Congress in 1978, utilities were required to pay an "avoided cost" value for customer-generated electricity. The value was typically set at the marginal price of fuel and ignored the capacity value the customer sited generation provided. In the 1990's, many states approved net metering policies for Investor Owned Utilities (IOU's) which credited the customer's production at the full retail cost of electricity. The methods used in the past typically did not produce a value of customer installed generation that properly reflect the long-term cost savings of the electric utility.

The following items were considered in determining the value of photo voltaic (PV), (solar).

1. Energy savings – The value of producing a kWh of electricity, the marginal energy costs are based on fuel and variable O&M costs of the generator most likely operating as the next generating unit (For MBLP a natural gas fired turbine generating unit was used in this analysis, which is consistent with the cost to construct the new Marquette Energy Center).
2. Generation capacity savings - The reductions in capacity provided by the distributed generation. This is determined by the cost of capacity times the distributed generations ability to reduce the peak demands of the Utility. Since the MBLP owns its' own generation capacity savings are minimal.
3. Loss savings – As energy is transmitted over the lines of an electric utility losses occur, placing the generation at the customer site reduces the utilities energy losses.
4. Transmission capacity savings – This is the ability of the distributed generating unit to reduce the cost of transmission to transmit energy from the point of production into the utilities local distribution system.
5. Environmental benefits – Reflect the savings from the reductions in carbon that occurs with solar distributed generation units. Currently this is not a direct cost to the MBLP and was not considered in this analysis.
6. Distribution system:
    a. Transformers, distribution lines, substations – Investments are made to reflect the peak demands of each customer and savings will occur in the long term if the distributed generation can reduce the required sizing on these facilities.
    b. Sub-transmission lines and substations – The investments in these facilities are to provide facilities to serve the peak demands of the system. Long term savings will occur if the distributed generation can reduce the impacts on the infrastructure designed to handle the peak demands of the system.

Summary Results

A summary of the results are listed in the tables below. The MBLP should consider a credit of 6.64 cents per kWh for solar for residential solar, 6.33 cents per kWh for community solar and 7.34 cents per kWh for commercial solar. You will notice that community solar has the lowest avoided cost credit per kWh since there is no realized savings in the infrastructure close to the community solar project (substation and sub transmission, distribution savings). The commercial class has a usage pattern that more closely matches the system peak loads. As a result, you will see that commercial solar has a higher avoided cost credit than residential solar due to the difference in their energy usage patterns. The detail calculations and assumptions used in the analysis are listed in the subsequent sections of this report. Note: The community solar rate does not include any maintenance cost. MBLP is expecting to roll the maintenance cost into the initial panel cost. Please see Appendix p11-p15 for load and production characteristics. You will see that solar production peaks and commercial load peaks more closely match. As a result the distribution savings are greater for solar – commercial**. This study was conducted using MBLP detailed hourly load data by meter and made possible as a result of their AMI system.**

No.		Solar - Residential	Community Solar
1	Production Capacity Savings	0.02052471	0.02052471
2	Energy Savings	0.04120441	0.04120441
3	Transmission Savings	0.00160211	0.00160211
4	Substation and Sub Transmission	0.00209718	-
5	Distribution Savings	0.00101864	-
	Total	**0.0664**	**0.0633**

No.		Solar - Commercial	
1	Production Capacity Savings	0.02052471	
2	Energy Savings	0.04120441	
3	Transmission Savings	0.00160211	
4	Substation and Sub Transmission	0.00209718	
5	Distribution Savings	0.00797457	
	Total	**0.0734**	

Assumptions / Project Approach

The long run marginal cost valuation assumed MBLP would construct a natural gas fired turbine generating unit. The section that follows details the calculations and assumptions used to determine value of distributed generation. This information is equivalent to next generating facility planned by MBLP.

A natural gas fired turbine generating unit operates as a base load generating unit and the study used the average all in cost on a per kWh basis. The all in costs used in this analysis was $1,340/kW. (Equivalent to $68 million for a 51 MW unit which is consistent to the cost of the new Marquette Energy Center)

Transmission

Transmission charges were broken down between peak demand charges of $.69 per kW. Transmission charges were derived from the 2013 cost of service study results.

Transmission Charges			
Peak Demand	$	0.69	kW

Distribution

The cost of service study completed in 2013 was used to identify the distribution savings for customer installed generation. Certain assumptions were made on a customer peak demand before and after the installation of solar. It was assumed there would be a 7% reduction in a customer's peak demand with the installation of an average solar unit.

Solar					
Distribution Cost		Rate	Factor	Adjusted Rate	Avoided Cost
Distribution		0.01326	93%	0.0124	0.0009
Transformer		0.00151	93%	0.0014	0.0001
Avoided Cost		**0.01477**			**0.001019**

The solar production projected from NREL (National Renewable Energy Laboratory) historical irradiance data. The table below identifies the solar production would have an annual capacity factor of 12.38%. The generation was compared with the system data for the MBLP to identify the potential reduction in the system peaks. This study used a sample kW solar install of 151.2 kW (the planned size of the MBLP community solar array). However, the average annual kWh solar production / KW of solar should be consistent across other fixed panel installations in the Marquette area. As a result, the 1,084 kWh average production can be applied to community solar, residential roof top as well as commercial roof top installations.

Table of projected solar production compared with MBLP system data

Average annual Solar production data							
Month	kW Unit	Days in Month	Hours in Month	kWH (Potential or Max if 100% capacity)	kWH Projected Produced	Projected Capacity factor	Production at time of System Peak - kW
1	151.2	31	744	112,492.80	3,956.24	3.52%	-
2	151.2	28	672	101,606.40	7,693.39	7.57%	-
3	151.2	31	744	112,492.80	15,321.64	13.62%	-
4	151.2	30	720	108,864.00	17,136.45	15.74%	34.16
5	151.2	31	744	112,492.80	21,285.01	18.92%	71.15
6	151.2	30	720	108,864.00	20,285.68	18.63%	65.35
7	151.2	31	744	112,492.80	20,620.79	18.33%	34.65
8	151.2	31	744	112,492.80	19,441.99	17.28%	98.52
9	151.2	30	720	108,864.00	15,266.22	14.02%	67.12
10	151.2	31	744	112,492.80	12,169.47	10.82%	-
11	151.2	30	720	108,864.00	6,667.78	6.12%	-
12	151.2	31	744	112,492.80	4,098.50	3.64%	-
				1,324,512.00	163,943.15	12.38%	370.94
					1,084		
					Average annual kWH solar production / KW of solar		

Solar savings and avoided cost

The solar savings considers savings in production capacity, transmission, energy, substation and sub transmission as well as distribution. This total is divided by the units produced to come up with an avoided cost per kWh. The average annual solar avoided cost is 6.64 cents per kWh for solar for residential solar, 6.33 cents per kWh for community solar and 7.34 cents per kWh for commercial solar. The respective avoided cost numbers assume a “buy all sell all” approach to metering and billing. If using a more traditional “net metering” scenario please see “residential net metering scenario” or “net billing scenario” on the following pages.

Avoided cost solar residential

Solar - Residential							
Month	Production Capacity Savings	Transmission Savings	Energy Savings		Substation and Sub Transmission	Distribution Savings	Total Savings	Avoided Cost per kWh
1	$ -	$ -	$ 163.01		$ -	$ 4.03	$ 167.04	$ 0.0422
2	$ -	$ -	$ 317.00		$ -	$ 7.84	324.84	0.0422
3	$ -	$ -	$ 631.32		$ -	$ 15.61	646.93	0.0422
4	$ 293.75	$ 24.19	$ 706.10		$ 30.015196	$ 17.46	1,071.51	0.0625
5	$ 611.68	$ 50.38	$ 877.04		$ 62.499829	$ 21.68	1,623.27	0.0763
6	$ 576.10	$ 46.27	$ 835.86		$ 58.864398	$ 20.66	1,537.75	0.0758
7	$ 354.74	$ 24.54	$ 849.67		$ 36.246638	$ 21.01	1,286.20	0.0624
8	$ 914.94	$ 69.76	$ 801.10		$ 93.486474	$ 19.80	1,899.08	0.0977
9	$ 613.68	$ 47.52	$ 629.04		$ 62.705043	$ 15.55	1,368.50	0.0896
10	$ -	$ -	$ 501.44		$ -	$ 12.40	513.83	0.0422
11	$ -	$ -	$ 274.74		$ -	$ 6.79	281.53	0.0422
12	$ -	$ -	$ 168.88		$ -	$ 4.17	173.05	0.0422
Total	**$ 3,364.89**	**$ 262.65**	**$ 6,755.18**	**$ -**	**$ 343.817578**	**$ 167.00**	**$ 10,893.54**	**0.0664**

Summary avoided cost solar Residential and community solar

No.		Solar - Residential	Community Solar
1	Production Capacity Savings	0.02052471	0.02052471
2	Energy Savings	0.04120441	0.04120441
3	Transmission Savings	0.00160211	0.00160211
4	Substation and Sub Transmission	0.00209718	-
5	Distribution Savings	0.00101864	-
	Total	**0.0664**	**0.0633**

Avoided cost solar commercial

Solar - Commercial								
Month	Production Capacity Savings	Transmission Savings	Energy Savings		Substation and Sub Transmission	Distribution Savings	Total Savings	Avoided Cost per kWh
1	$ -	$ -	$ 163.01		$ -	$ 31.55	$ 194.56	$0.0492
2	$ -	$ -	$ 317.00		$ -	$ 61.35	378.35	0.0492
3	$ -	$ -	$ 631.32		$ -	$ 122.18	753.50	0.0492
4	$ 293.75	$ 24.19	$ 706.10		$ 30.015196	$ 136.66	1,190.71	0.0695
5	$ 611.68	$ 50.38	$ 877.04		$ 62.499829	$ 169.74	1,771.33	0.0832
6	$ 576.10	$ 46.27	$ 835.86		$ 58.864398	$ 161.77	1,678.86	0.0828
7	$ 354.74	$ 24.54	$ 849.67		$ 36.246638	$ 164.44	1,429.63	0.0693
8	$ 914.94	$ 69.76	$ 801.10		$ 93.486474	$ 155.04	2,034.32	0.1046
9	$ 613.68	$ 47.52	$ 629.04		$ 62.705043	$ 121.74	1,474.69	0.0966
10	$ -	$ -	$ 501.44		$ -	$ 97.05	598.48	0.0492
11	$ -	$ -	$ 274.74		$ -	$ 53.17	327.91	0.0492
12	$ -	$ -	$ 168.88		$ -	$ 32.68	201.56	0.0492
Total	**$ 3,364.89**	**$ 262.65**	**$ 6,755.18**	**$ -**	**$ 343.817578**	**$ 1,307.38**	**$ 12,033.91**	**0.0734**

* Note: The average residential rate below was calculated from an average inside city and outside city based on the planned rate schedules anticipated to be effective October 1, 2016. This amount is the average total revenue for these two rate schedules divided by the total estimated kWh sales. The total revenue does not include the customer charge nor does it include PCA. This additional monthly charge per kW of installed solar calculation will need to be updated as the average residential rate changes and / or as the PCA changes.

Residential Net metering scenario

Residential Charge per kW of Solar Installation		
Average Residential Rate *	$	0.13610
PCA	$	(0.00790)
Average Net Rate (Residential and PCA)	$	0.12820
Avoided Cost		0.0664
Lost Revenues per kWh		0.0618
Annual kWh production from 1 kW of Solar		1,084
Annual Under-Recovery from Solar	$	66.96
Additional Monthly Charge per kW of installed Solar	**$**	**5.58**
* Average Energy Rate (less customer charge, less PCA) from rate design model		

* Note: The average commercial rate below was calculated from an average "all other than residential" based on the planned rate schedules anticipated to be effective October 1, 2016. This amount is the average total revenue for these rate schedules divided by the total estimated kWh sales. The total revenue does not include the customer charge nor does it include PCA. This additional monthly charge per kW of installed solar calculation will need to be updated as the average commercial ("all other than residential") rate changes and / or as the PCA changes.

Commercial Net metering scenario

Commercial Charge per kW of Solar Installation		
Average Commercial Rate *	$	0.15020
PCA	$	(0.00790)
Average Net Rate (Commercial and PCA)	$	0.14230
Avoided Cost		0.0734
Lost Revenues per kWh		0.0689
Annual kWh production from 1 kW of Solar		1,084
Annual Under-Recovery from Solar	$	74.70
Additional Monthly Charge per kW of installed Solar	**$**	**6.23**
* Average Energy Rate (less customer charge, less PCA) from rate design model		

Recommendations

1. MBLP should apply the following values in the determination of rate impacts to customers.

   Buy all sell all options

   a. Residential roof top solar - 6.64 cents per kWh
   b. Community Solar Project - 6.33 cents per kWh
   c. Commercial roof top solar - 7.34 cents per kWh

   Net metering options

   d. Residential net metering scenario - $5.58 additional monthly charge per kW of installed solar
   e. Commercial net metering scenario - $6.23 additional monthly charge per kW of installed solar

   Net billing options

   f. Residential roof top solar - 6.64 cents per kWh
   g. Commercial roof top solar - 7.34 cents per kWh

2. The analysis is based on long-run marginal costs (avoided cost) and load profile data from the renewable units compared with MBLP total system profile. Both the load profile and long-run marginal costs will change over time and MBLP should consider reviewing the kWh values periodically.

Metering and billing options defined

Buy all sell all

Under a buy all sell all metering and billing scenario two meters will be required. All power used by the customer will be supplied by the utility. This utility supplied power will be metered and billed at the current normal utility rates. The solar production will be metered by the second meter. All solar production will be sent back to the utility grid and credited at the current avoided cost. This option is recommended for the community solar project. This option is occasionally used for larger commercial customers. This option is typically not used for residential roof top solar.

Buy all sell all summary

Metering: Two meters are required with a buy all sell all scenario. One meter is for power supplied by the utility to the customer. A second meter is used for solar production sent back to the utility by the customer.

Solar Production: All solar production gets sent back to the utility. The customer only uses power supplied by the utility.

Billing: The utility sells all the power to the customer at the normal rate. The utility buys all of the solar production at the avoided cost. (A, B and C above)

Metering and billing options defined

Net metering

Under a net metering scenario only one meter will be required. Net metering can be done under two different metering options. The first option is a meter that "spins both ways". This type of meter will spin forward when power is being used from the utility. This meter will then spin in reverse when excess solar production is being sent back to the utility. The second option is a meter that tracks the "in and out" separately. The utility supplied power in will be tracked and the solar production excess sent back to the utility is tracked separately. These two numbers can be netted for billing at the current normal utility rates. Under both metering options under net metering the customer bill will be the same. At the end of the billing cycle the net usage will be billed at the current normal utility rates. If there is a billing cycle that there is more power sent back to the utility than power supplied by the utility the excess solar production will be credited at the current normal utility rates. The customer is charged an additional monthly charge per kW of installed solar. This option is generally used for commercial and residential roof top solar customers. Some utilities will limit the dollar amount and/or number of months that an over production of solar will be allowed to be credited.

Net metering summary

Metering: Only one meter is required with a net metering scenario. One meter is for power supplied by the utility to the customer. The same meter is used for solar production sent back to the utility by the customer. The two most typical single net meter options are a meter that spins both ways or a meter that tracks the in and out separately. Both meters should allow for the same customer bill to be calculated.
Solar Production: Only excess solar production gets sent back to the utility. The customer only uses power supplied by the utility when solar production does not meet their usage needs.
Billing: The utility sells all the power to the customer at the normal rate. The utility buys the excess solar production at the normal rate. (Net usage based on two metering options above) The customer is credited at normal rates if more solar production is sent to the utility then used from the utility. The customer is charged an additional monthly charge per kW of installed solar. (D and E above)

Metering and billing options defined

Net billing

Under a net billing scenario only one meter will be required. Net billing is typically done when the utility only has meters that spin both ways. At the end of the billing cycle the net usage will be billed at the current normal utility rates. If there is a billing cycle that there is more power sent back to the utility than power supplied by the utility the excess solar production will be credited at the current avoided cost. This option is generally used for commercial and residential roof top solar customers. Some utilities will limit the dollar amount and/or number of months that an over production of solar will be allowed to be credited.

Net billing summary

Metering: Only one meter is required with a net billing scenario. One meter is for power supplied by the utility to the customer. The same meter is used for solar production sent back to the utility by the customer. This typical single net meter option is a meter that spins both ways.

Solar Production: Only excess solar production gets sent back to the utility. The customer only uses power supplied by the utility when solar production does not meet their usage needs.

Billing: The utility sells all the power to the customer at the normal rate. The utility buys the excess solar production at the avoided cost. This only happens when there is a billing cycle that there is more power sent back to the utility than power supplied by the utility. (F and G above)

Appendix of Load Characteristics

The charts below are summaries of the load profiles used for the MBLP system and solar generation. **This study was conducted using MBLP detailed hourly load data by meter and made possible as a result of their AMI system.**

MBLP's system load profile comparing the MWH, peak demand of system, date and time of system peaks (2013-2015 average system load data used).

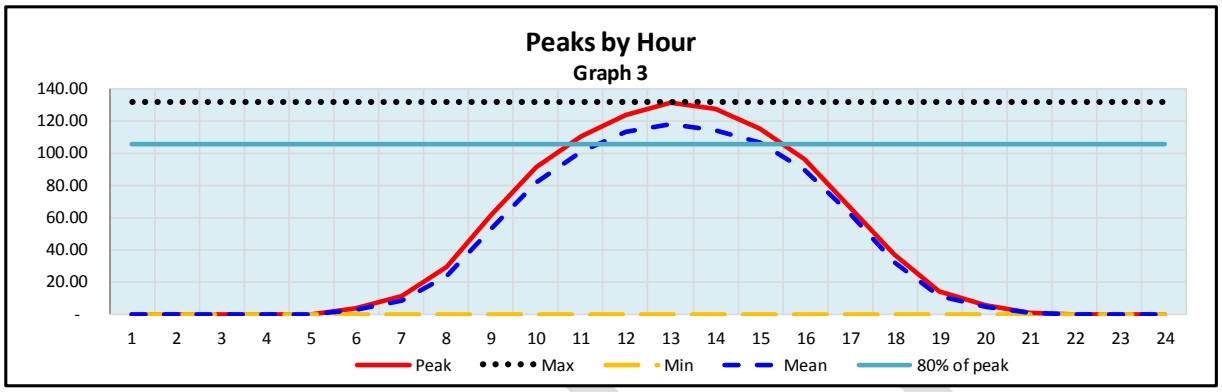
System Load									
Month	Assigned Season	MWhs in Month	Peak Demand Month (MW)	Days in Month	Hours in Month	Monthly Load Factor	System Peak Hour	System Peak Date	System Peak Day
January	W	33,330	55.38	31	744	81%	19	1/20/2015	Tuesday
February	W	30,050	53.66	28	672	83%	19	2/4/2015	Wednesday
March	W	30,563	51.09	31	744	80%	20	3/4/2015	Wednesday
April	INTER4	27,144	45.84	30	720	82%	11	4/3/2015	Friday
May	INTER4	26,374	45.66	31	744	78%	13	5/29/2015	Friday
June	INTER2	26,614	49.93	30	720	74%	13	6/29/2015	Monday
July	S	30,108	54.92	31	744	74%	16	7/20/2015	Monday
August	S	30,127	53.61	31	744	76%	14	8/24/2015	Monday
September	INTER2	28,584	52.94	30	720	75%	15	9/1/2015	Tuesday
October	INTER4	28,293	46.64	31	744	82%	19	10/26/2015	Monday
November	INTER4	28,966	52.27	30	720	77%	19	11/30/2015	Monday
December	W	31,781	53.77	31	744	79%	19	12/8/2015	Tuesday
TOTAL		351,934	616	365	8,760				

Summary of average system usage by hour and season:

	AVERAGE MWh BY SEASON			
Hour	S	W	INTER2	INTER4
1	31.56	35.92	29.58	29.92
2	30.54	34.69	28.71	29.08
3	30.06	34.06	28.29	28.72
4	30.44	34.01	28.78	29.11
5	32.25	34.95	30.75	30.88
6	34.80	37.41	33.84	34.05
7	37.34	41.12	36.85	37.15
8	40.46	44.25	39.40	39.66
9	43.22	45.99	41.47	41.02
10	45.29	46.68	43.10	41.98
11	46.60	47.36	44.01	42.46
12	47.27	47.51	44.44	42.51
13	47.62	47.25	44.50	42.34
14	47.58	46.81	44.41	41.98
15	47.55	46.45	44.41	41.82
16	47.38	46.44	44.35	41.87
17	46.57	47.03	43.66	41.85
18	45.31	48.46	42.59	42.12
19	44.16	49.55	41.99	42.38
20	43.22	49.65	41.89	42.07
21	42.48	48.17	40.31	40.93
22	40.02	45.21	37.54	37.92
23	36.44	41.70	34.02	34.53
24	33.38	38.39	31.09	31.66

Appendix of Production Characteristics

Projected Solar Production Characteristics



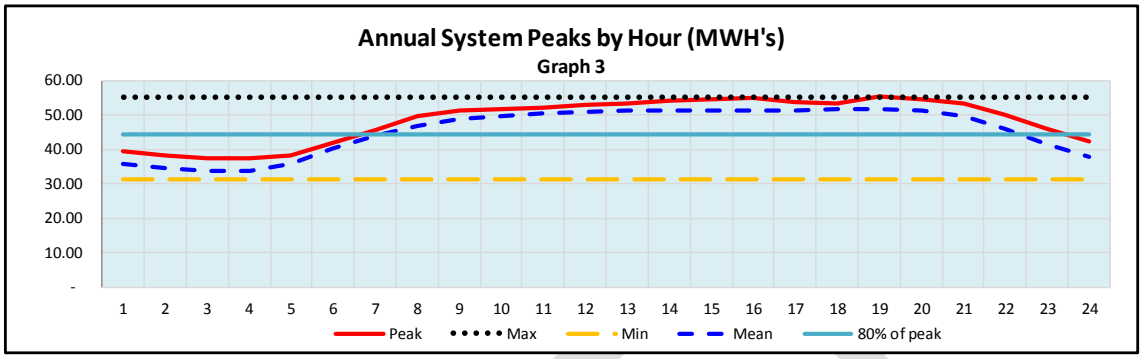
NREL Irradiance data 151.2kW

Production Peak Summary

Month	Peak kW	Peak Hour	Peak Date
January	42.37	13	1/13/2015
February	72.62	13	2/16/2015
March	99.81	13	3/3/2015
April	121.69	13	4/29/2015
May	131.54	13	5/8/2015
June	117.31	13	6/3/2015
July	119.93	13	7/4/2015
August	117.01	13	8/25/2015
September	118.67	13	9/28/2015
October	117.69	13	10/17/2015
November	90.87	13	11/10/2015
December	51.59	14	12/31/2015

Appendix of Load Characteristics

Historical System Load Characteristics (2013-2015 average)



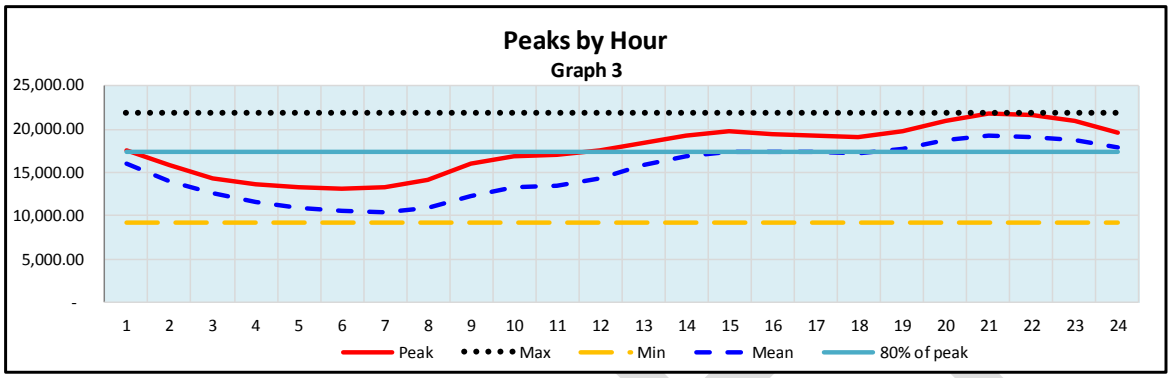
Demand Peak Summary

Month	Peak	Peak Hour	Peak Date
January	55.38	19	1/20/2015
February	53.66	19	2/4/2015
March	51.09	20	3/4/2015
April	45.84	11	4/3/2015
May	45.66	13	5/29/2015
June	49.93	13	6/29/2015
July	54.92	16	7/20/2015
August	53.61	14	8/24/2015
September	52.94	15	9/1/2015
October	46.64	19	10/26/2015
November	52.27	19	11/30/2015
December	53.77	19	12/8/2015

Appendix of Load Characteristics

You will see that solar production peaks and residential load peaks are not as coincident. As a result the distribution savings are less for solar – residential.

(Residential) Historical Class 1 and 2 Load Characteristics



Rate Class 1 and 2

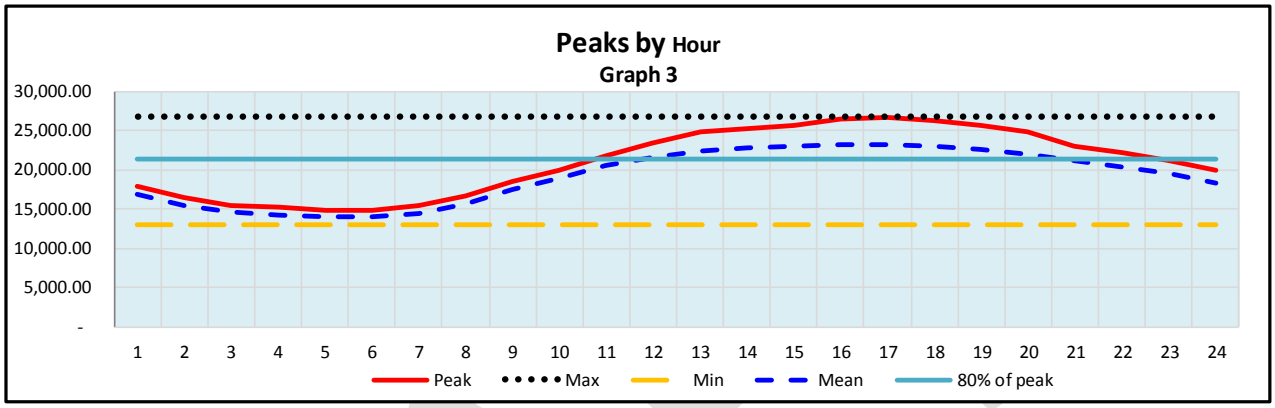
Demand Peak Summary

Month	Peak kW	Peak Hour	Peak Date
January	21,801	21	1/4/2015
February	20,950	21	2/14/2015
March	18,651	22	3/4/2015
April	15,187	23	4/1/2015
May	14,059	22	5/12/2015
June	13,532	23	6/29/2015
July	18,593	22	7/27/2015
August	18,813	24	8/16/2015
September	17,996	24	9/1/2015
October	15,782	22	10/25/2015
November	18,368	21	11/29/2015
December	19,056	21	12/28/2015

Appendix of Load Characteristics

You will see that solar production peaks and commercial load peaks more closely match. As a result the distribution savings are greater for solar – commercial.

(Commercial) Historical Class 3. 4, 5, 6 and 7 Load Characteristics



Rate Class 3 4 5 6 and 7

Demand Peak Summary

Month	Peak kW	Peak Hour	Peak Date
January	20,285	13	1/8/2015
February	19,658	14	2/20/2015
March	18,992	13	3/6/2015
April	17,816	16	4/16/2015
May	20,628	17	5/29/2015
June	21,198	16	6/29/2015
July	25,800	16	7/27/2015
August	25,172	18	8/31/2015
September	26,772	17	9/1/2015
October	20,688	16	10/12/2015
November	20,153	14	11/5/2015
December	20,396	14	12/18/2015

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ACCOUNTANTS' COMPILATION REPORT

Marquette Board of Light & Power
Board of Directors
2200 Wright Street
Marquette MI 49855

The purpose of this report is to assist management in determining the value of solar. This report should not be used for any other purpose.

The accompanying renewables valuation study for the MBLP Electric Department was compiled with average hourly system load data for the calendar years 2013-2015. The system load data used was supplied by MBLP. Since MBLP had no solar production data, data anticipated to be similar to MBLP was used. Solar production data used was from NREL (National Renewable Energy Laboratory). This data was than aligned with historical average snow loss days from www.currentresults.com.

Differences between historical (NREL production data used) and actual MBLP results will occur since some assumptions may not materialize and events and circumstances may occur that were not anticipated. Some of these variations may be material. Utility Financial Solutions, LLC has no responsibility to update this report after the date of this report. However, it is recommended that MBLP update this study as base assumptions used materially change.

This report is intended for information and use by management and the Board of Directors for the purposes stated above. This report is not intended to be used by anyone except the specified parties.

UTILITY FINANCIAL SOLUTIONS, LLC

Mark Beauchamp, CPA, CMA, MBA
May 4, 2016