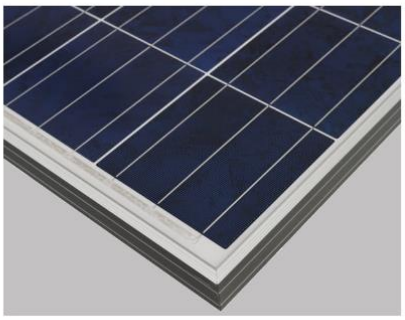
- Tests by independent laboratories prove that Yingli Solar modules:
  - Fully conform to certification and regulatory standards.
  - Withstand wind loads of up to 2.4kPa and snow loads of up to 5.4kPa, confirming mechanical stability.
  - Successfully endure ammonia and salt-mist exposure at the highest severity level, ensuring their performance in adverse conditions.
- Manufacturing facility certified by TÜV Rheinland to ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007.



WARRANTIES

- 10-year limited product warranty[1].
- Limited power warranty[1]: 10 years at 91.2% of the minimal rated power output, 25 years at 80.7% of the minimal rated power output.

[1]In compliance with our Warranty Terms and Conditions.

QUALIFICATIONS & CERTIFICATES

IEC 61215, IEC 61730, MCS, CE, ISO 9001:2008, ISO 14001:2004, BS OHSAS 18001:2007, SA 8000, PV Cycle

YINGLISOLAR.COM

https://pvwatts.nrel.gov/pvwatts.php 1/1

Product Name Nanopower SC

Provided by Nanopower International LLC

Traverse & CBS Solar Project

Alternative Energy Enterprise - Fall Final Report

December 4, 2018

Advisor: **Jay Meldrum**

Team Members:

Asa Pierce **Chris Rye** **William Turkovich**

Table of Contents

Introduction

This year's Solar Team is working with two products from two companies in the solar industry, Traverse Solar and CBS Solar. The Team has tasked to use university-backed research to confirm the claims of increased efficiency and performance of solar technology by their products. Traverse Solar implements a single axis daily solar tracking device for their panels that keeps the panel in line with the sun throughout the day [1]; CBS provides a coating for commercial solar panels that boasts increased efficiency, lower maintenance, and higher life expectancy [2]. Additionally, the Solar Team was task to create a solar panel system downstate that would supply the house with a significant portion of their power. The team created three variations of this system based on a property in downstate Michigan [3].

Motivation

Houghton, Michigan has residential electric costs that are 37% higher than the state average [4]. Given this fact, it is important to explore the multitude of alternative ways to generate power. With the Houghton area getting around 3.9 kWh/m2/day whereas other parts of the state gets anywhere from 4 to 4.4 kWh/m2/day [5], it is especially important to focus on the efficiency of these generation methods. With each improvement to efficiency, a resident can reduce the cost of their electric bill. Two ways that could improve the efficiency of solar panels are solar trackers, and self-cleaning coating.

The Solar Team was able to obtain a single axis solar tracker from Traverse Solar, and a self-cleaning solar panel coating from CBS Solar. The Solar Team's goal is to prove the claims of both of these system improvements, leading to better solar power generation in the Upper Peninsula.

Background

With the advancement of solar panel technology, several unique efficiency methods have been developed**.** Some of these methods are standard in the industry, while others have yet to be thoroughly examined and proven useful. CBS Solar and Traverse Solar both provide a unique solution to the question of efficiency. Some of the claims made by these companies could benefit from further studies. Traverse Solar claims to have up to 40% increased power generation, with around 30% power increase in the upper Michigan. CBS Solar claims to have 6% increased solar absorption, and breaks down dirt, smoke, and bacteria.

Results

I. Mounting the Solar Panels

On October 4th, the Solar Team went to the Keweenaw Research Center (KRC) to install and adjust a few of the solar panels for the project. With the help of Nolan Osborne, they adjusted the angle of the Traverse Solar panels on their mount. Additionally, they installed two solar panels that would be used as control for the CBS Solar Project. On November 14th, a member from the KRC installed cameras that monitor the panels, saving images every 15 minutes.

II. Enphase

All of the relevant solar panels used for the Traverse Solar Project and CBS Solar Project were linked to Enphase brand microinverters (MI). Microinverters take the DC voltage produced by the panels and converts it into a standard frequency AC voltage. Several panels can be hooked up in series with one MI, or the panels can be hooked up in parallel, each with its own MI. The panels at the KRC are hooked up in parallel. This allows for precise measurements using Enphase software. Their software [6] allows for the remote tracking of data from the solar panels, such as power and energy. This data can then be viewed in the software as graphs and tables, or exported as Excel-compatible files for further analysis.

III. Preliminary Results

Traverse
Between 10/1/18 to 12/11/18 for days that met or exceeded 2.50 inches [7] of snowfall Traverse Solar outperformed the control panels around 70% of the time. Given time for more data collection the team predicts that percentage to increase. There are several variables at play that could skew the data in favor of the control panels on a day by day basis. For one, data gathered from the MI snowfall record collected snowfall through the night not just during the day. This means there were some days that saw plenty of sun through the day and snowed when the panels were not producing. This throws off our standard deviation of energy produced but not our accuracy of the comparison between panels.

Next is wind, both panels saw westward winds which can mean irregularity in snow coverage over panels. Through close monitoring with time lapse cameras, there was not a noticeable difference in snow coverage due to wind. We did however notice that Traverse consistently had less snow accumulation on the higher portions of the panel, and attribute this to its ability to move throughout the month.

The most impressive data from Traverse so far is the total energy produced compared to the traditional stationary panels. In the first two months of collecting data we found over a 100% increased efficiency from Traverse Solar mounting system compared to a stationary system (in Table 1). This means that not only does Traverse outperform handling the snow, but they consistently outperform throughout the month by adjusting its position relative to the sun by a larger factor. By adjusting the angle of the solar panel to be more perpendicular to the sun, the more solar radiation that panel will receive, thus more energy output.

Table 1. Traverse Panels Compared to Control.

	Amount	AVG Energy produced by Control (Wh)	AVG Energy produced by Traverse
Days W/ >=2.50in Snowfall			
2.50	11/8	13	11
10.00	11/9	7.25	7.5
4.00	11/11	125.25	62.5
3.00	11/18	74.5	74
6.00	11/19	263.5	361.5
2.50	11/27	39.75	64
8.00	12/5	60.25	77
5.00	12/6	17.5	22.5
10.00	12/7	14.5	21
AVG total energy	11/1-12/11	4889.5	8493

CBS

The Solar Team's data for CBS gave some surprising preliminary results compared to the predictions made. The CBS coating applied to two solar panels compared to the two nearest control panels yielded very similar results when handling the snowfall during the same month and a half period where the Traverse panels saw at or over 2.5 inches of snow per day. Three of those days both the control and the CBS coated panels saw only a difference of half a watt hour.

During November, the average daily percentage of maximum power for each CBS panel was over 18% while the control was around 14%. This was calculated by taking the average amount of sun hours the UP saw over the month and dividing it by total optimal output of each panel. Each panel was capable of producing 2,250 Wh of power per day seeing 9 hours of sun. The low percentage of max output can be attributed to seeing less that the optimal 9 hours of sunlight due to weather conditions and other obstructions like snow.

In the small preliminary sample size of data, CBS did outperform the control panels 50% of the time. During the times CBS outperformed, it was only by a few watt hours margin. The CBS coating was not meant to boost performance to a major degree, their main focus was to reduce the amount of particulate matter that can gather on panels and wear them down over time.

However, CBS claims a small boost in efficiency of just 6%, and according to the data they are on track to being right about that. Over the month of November, 2018 and for days with snow CBS produced 3-5% more than the control panels in total energy production. With a small sample size and a small degree of difference in efficiency, there isn't enough evidence yet to support the 6% boost in efficiency (in Table 2).

Table 2. CBS Panels Compared to Control.

Days W/ snow >=2.5 inches	AVG CBS (Wh)	AVG CBS control (Wh)	All November	AVG CBS (Wh)	AVG CBS control (Wh)
11/8	5	5.5	Per day	408.50	316
11/9	5	5.5	Total	9796	9495
11/11	74	65.5	Total capacity per day	2250	2250
11/18	35	35.5	Percent used of max output	18.16	14.04
11/19	47.5	45			
11/27	64	13.5			
12/5	18	19.5			
12/6	22.5	12			
12/7	12	24			
Per day	163.27	158.25			
Total	10,666	10,119			

IV. Downstate Solar Panel Project

Another side project given to the Solar Team was to complete a theoretical solar sizing for a house in Lower Michigan based off of one of the member's parent's electric bills for the year. The team decided to use Asa Pierce's home, located at 2145 W Barnes Rd. Mason, Michigan.

Using the National Renewable Energy Lab (NREL) program for solar design, PVWATTS can be used for designing solar in any location. This website takes in many variables such as Size of system, Array Type, System Losses, Tilt, and Azimuth. After doing some calculations, the site determines Solar Radiation / square meter / day, AC energy (per month) and Average Value (in dollars) each month.

In Appendix A, from the electric bill, the household used 9,706 kWh total throughout the year. That will be the base number to use when estimating how many solar panels, so on average that is approximately 808 kWh a month, or 26 kWh a day. In the location of the household (in Lower Michigan), the average cost per kilowatt hour was 16 cents. There are three example sizings, 50% cost on roof, 50% cost on ground, and 100%, off grid, on the ground.

Figure 1. Available solar panel space at 2145 W Barnes Rd.

For roof mounting the house has two sections of roof, both at 20 degrees° and 225° Azimuth. In Figure 1. Above, there is a maximum area on roof section A of 846 square feet, and section B of 450 square feet. With panels the same size as the ones at the KRC, the maximum amount of panels that can fit on both roofs is sixty-three placed portrait orientation. To accomplish 50% power generation the roof mounted array has to produce around 4,000 kWh of energy a year [8]. This means the house would need a 4 kW DC system in size, that in turn requires 18 mounted solar panels on the roof. By simplifying the costs of solar panels, installation, and voltage conversion, a round $5/watt estimate will be used. For a 4 kW system, that would be approximately $20,000 in initial cost. With the solar panels producing a yearly value of $665 of electricity, these panels would pay for themselves in thirty years.

For a ground mounted system, the household owns a yard adjacent to the house that would be suitable for a solar array. The panels would be facing south, an Azimuth of 180°, and fixed in a position of 45° tilt all year. To produce 50% of needed power, according to PVWATTS [8], the house would need a 3.8 kW DC system size, equaling fifteen, 255 watt solar panels. Again using

the $5/watt simple estimation, that would be an initial cost of $19,000. These panels would annually produce half of the energy the household uses at a value of $673 per year. The system would be paid back in twenty-eight years.

If the household wanted to produce 100% of their annual electricity only with solar panels, they would need to generate 9,706 kWh of energy. With the help of PVWATTS [8], a 7.8 kW DC system would produce 9,887 kWh, just over the annual need. To produce 7.8kW the needed solar panels is thirty-one 255W solar panels, mounted on the ground with a tilt of 45° and Azimuth of 180°. Luckily, in Figure 1. Above, there is enough room to mount them all. With $5/watt the initial cost for the system would be $39,000. The system would produce a value of $1,346 in electricity every year. It would take just under 29 years to pay back the initial cost needed.

After all of this cost analysis, there is a Government offers a federal tax credit for 30% off of solar installations. If the system was bought when this credit is valid it would only cost $14,000 for the 4kW system and have a quicker payback period of 21 years. The 100% annual energy system would only cost $27,300 with the tax credit. This system would pay for itself in just over 20 years, after that the household would produce free electricity at a positive value of $1,346 every year.

V. Life Cycle Analysis

There are many steps to the life cycle analysis of the Traverse Solar and CBS Solar panel systems. In the future, the Solar Team would like to plot out an in-depth life cycle analysis, but for now, each step will be outlined. First, the materials are gathered for the inverters, the panels themselves, the mounting systems, and for CBS, the coating. The assembly, coating, and installation of the solar panels each have energy costs and a level of emissions associated with them. Without any issues arising, the panel would be self-sustaining for 25 years at a baseline of 80.7% minimal production, as seen in Appendix C. The CBS coating is under a 20 year warranty for solar panels [2]. After these points, the panels would have to be disposed of, with the reusable parts recycled for future use.

VI. Safety

The Solar Team passed the safety exam in November. The Solar Team did not have to many situations where safety was a large risk because most of this project was done on a computer. As for the installation of the panels to the Traverse equipment, the team always had one person holding the panel in place as another person fastened the screws for positioning. For the electrical hook-up, Nolan Osborne at the KRC facilitated that portion of the installation.

Conclusion

- Traverse came to the Solar Team looking for university backed proof that their claim of increased efficiency was true for anyone looking to invest in residential solar. Traverse understands that even as the costs of residential solar decrease, it is still a major investment for homeowners and business owners alike. With the Traverse single axis solar tracking system, Traverse boasts a 30-40% increase in efficiency over the year, specifically in the Upper Peninsula. As we enter the shortest days and heaviest snowfalls of the year the Solar Team will hope to see a continued trend in snow reduction and consistent efficiency from Traverse.

  This was a major claim, and sounds too good to be true. It is easy to be skeptical of solar in the UP when it is no oddity to see 10 plus inches of snowfall some nights in the winter. The Solar Team was put to the task of holding Traverse to their numbers, and after a heavy dose of snow over the past two months we have solid preliminary data. We found that Traverse certainly met their claims of efficiency and exceeded it.

- The CBS Coating solar is meant to protect solar panels from the harsh outside conditions that Michigan can muster. CBS claims that their coating seals away the solar panel's components from dust, water, mold, and snow particles that can bog down efficiency and wear down solar panels over time.

  During the time the Solar Team collected data over the semester, the panels were exposed to many days of snowfall. The days there was snow, CBS outshined the control panels half of the time, and overall there was a small increase in efficiency close to the amount CBS claimed. The Team has not extended the study to include CBS' effectiveness against anything besides snow and water, and doing so would take more time to monitor the status of the panels over time and during the spring/summer seasons. At the end of the semester CBS shows promise of coming close or meeting the benchmark of their efficiency claims, but requires more studies to be done on its effectiveness for preventing elemental erosion of the panels.

- For the downstate solar project, without having the 30% federal tax credit, the system would not be able to pay for itself before the rated amount of years the components break down. If the federal tax credit is used for 30% of the system, then each system will pay for itself with approximately four to five years of free electricity, plus the owner can feel good about reducing contribution toward climate change whilst making some money.

Future Work

The Solar Project has succeeding in setting up a system that can be monitored and analyzed. Once a significant amount of data has been recorded, the Solar Team plans to create a much more comprehensive analysis of this data. Using the analysis, the team can come to a conclusion to the question of each methods' efficiency. Additionally, The Solar Team could use this data to think of ways to improve the efficiency.

Currently, there is no power measurement being taken on the Traverse Solar mount's motor. The Solar Team has a few options to approach this. The team could measure this data alongside the panel data, record the motor over a few days and use this as an estimate for future projections, or they could get the information about the motor, and calculated the energy used each day to implement into their calculations. Accounting for the motor is an important aspect that could prove the efficiency to be lower than first thought.

For a more in-depth analysis of the solar panel system, the Solar Team would like to create a thorough life cycle analysis. This data would be useful to compare solar against other forms of power generation, or even the compare a solar tracking system versus a system without solar tracking. Using the life cycle analysis, further improvements could be made to the sustainability of the solar tracker.

References

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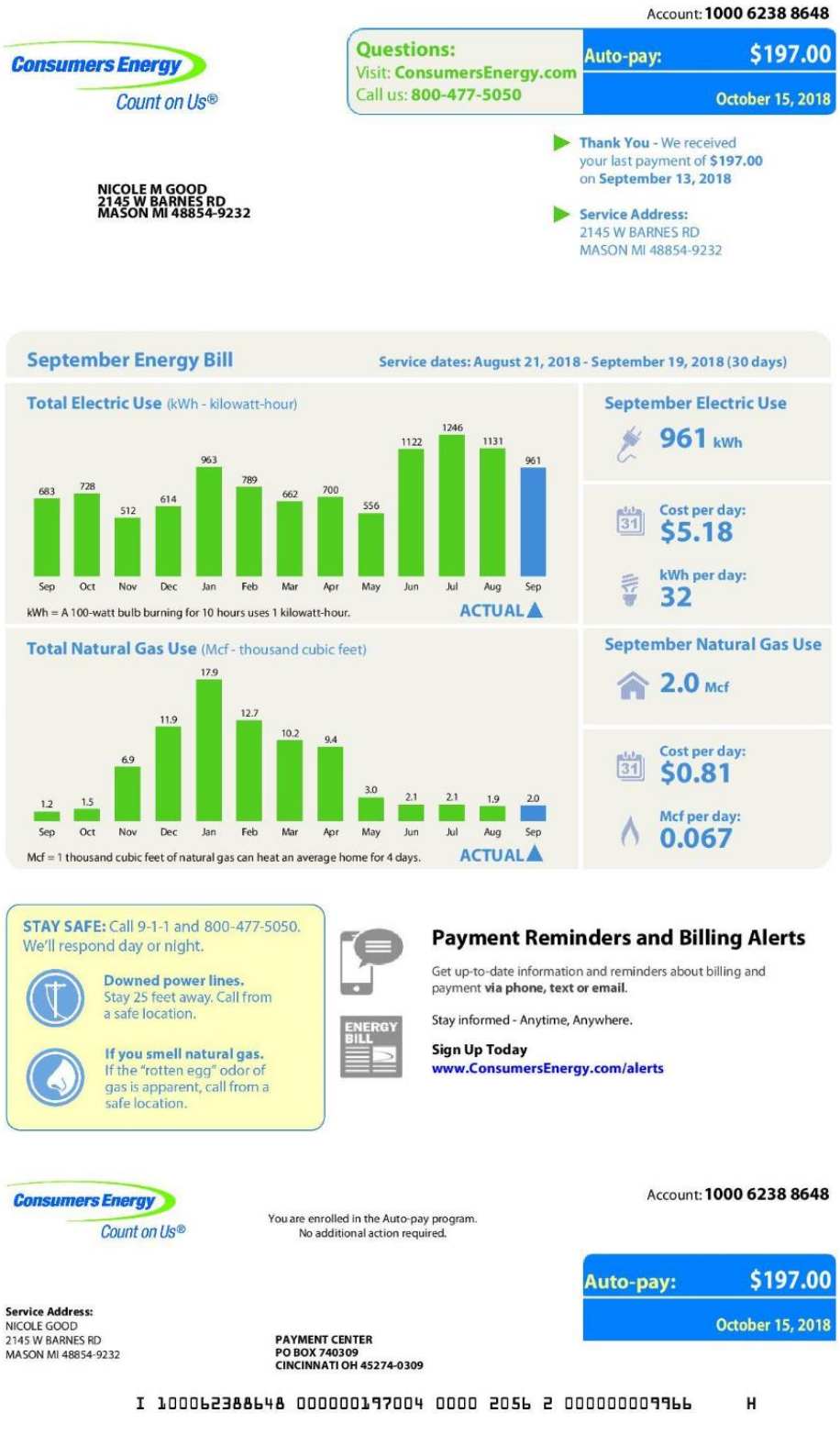
[3] Pierce, A., Rye, C. and Turkovich, W. (2018). *Solar Power*. [online] Alternative Energy Enterprise. Available at: http://aee-mtu.org/teams/solar.html [Accessed 13 Dec. 2018].
[4] "Houghton, MI Electricity Statistics," *Electricity Local*. [Online]. Available: https://www.electricitylocal.com/states/michigan/houghton/. [Accessed: 13-Dec-2018].
[5] NREL. (n.d.). *Solar Maps*. [online] Available at: https://www.nrel.gov/gis/solar.html
[6] Enlighten. (2008). *Enphase*. [online] Available at: https://enlighten.enphaseenergy.com/

[7] Keweenaw County Online. (2018). *Keweenaw County Snowfall Amounts*. [online] Available at: http://www.keweenawcountyonline.org/snowfall2.php [Accessed 14 Dec. 2018].
[8] PVWatts. (n.d). *PVWatts Calculator*. [online] Available at: https://pvwatts.nrel.gov/pvwatts.php

Appendix A



Account: **1000 6238 8648**

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Call us: **800-477-5050**

Auto-pay: **$197.00**
October 15, 2018

Thank You - We received your last payment of **$197.00** on **September 13, 2018**

Service Address:
2145 W BARNES RD
MASON MI 48854-9232

NICOLE M GOOD
2145 W BARNES RD
MASON MI 48854-9232

September Energy Bill — **Service dates: August 21, 2018 - September 19, 2018 (30 days)**

Total Electric Use (kWh - kilowatt-hour)

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
683	728	512	614	963	789	662	700	556	1122	1246	1131	961

kWh = A 100-watt bulb burning for 10 hours uses 1 kilowatt-hour. ACTUAL

September Electric Use
961 kWh
Cost per day: **$5.18**
kWh per day: **32**

Total Natural Gas Use (Mcf - thousand cubic feet)

Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
1.2	1.5	6.9	11.9	17.9	12.7	10.2	9.4	3.0	2.1	2.1	1.9	2.0

Mcf = 1 thousand cubic feet of natural gas can heat an average home for 4 days. ACTUAL

September Natural Gas Use
2.0 Mcf
Cost per day: **$0.81**
Mcf per day: **0.067**

STAY SAFE: Call 9-1-1 and 800-477-5050. We'll respond day or night.

Downed power lines. Stay 25 feet away. Call from a safe location.

If you smell natural gas. If the "rotten egg" odor of gas is apparent, call from a safe location.

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Account: **1000 6238 8648**

Auto-pay: **$197.00**
October 15, 2018

Service Address:
NICOLE GOOD
2145 W BARNES RD
MASON MI 48854-9232

PAYMENT CENTER
PO BOX 740309
CINCINNATI OH 45274-0309

I 100062388648 000000197004 0000 2056 2 000000009966 H

16 EBILL 09/18

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Need to talk to us? Visit **ConsumersEnergy.com**
or call **800-477-5050**
Hearing/speech impaired: Call 7-1-1

Service Address:
2145 W BARNES RD; MASON MI 48854-9232

Account: **1000 6238 8648**

Account Information

Bill Month: September
Service Dates: 08/21/2018 - 09/19/2018
Days Billed: 30
Portion: 16 09/18

Programs:
Auto Pay
Budget Plan

Rate Information

Electric Residential Service
Rate Code: 1000

Gas Residential Service
Rate Code: 250

Meter Information

Your next scheduled meter read date is on or around 10/17/2018

Electric Service: Smart Meter
Meter Number: 31238140
POD Number: 0000000640645
Beginning Read Date: 08-21
Ending Read Date: 09-19
Beginning Read: 14314
Ending Read: 15275 (Actual)
Usage: 961 kWh

Total Metered Energy Use: 961 kWh

Gas Service: Smart Meter
Meter Number: 94024080
POD Number: 0000000640646
Beginning Read Date: 08-21
Ending Read Date: 09-19
Beginning Read: 4979
Ending Read: 4999 (Actual)
Differential: 20
Constant: 0.1
Correction factor: 1.00000
Usage: 2.0 Mcf

Total Metered Energy Use: 2.0 Mcf

September Energy Bill

Invoice: 203853153161

Budget Plan and Other Charges Summary

Last Month's Amount Due in Budget Plan	$197.00
Payment on Sep 13, 2018	$197.00-
Scheduled Budget Payment	$197.00
Amount Due	**$197.00**

Electric Charges

Energy-First 600 kWh	600@ 0.094603	$56.76
Energy-Over 600 kWh	361@ 0.127339	$45.97
Cap. Tax Reform Credit	961@ 0.001704-	$1.64-
PSCR	961@ 0.005020-	$4.82-
Green Generation Block	1@ 1.500000	$1.50
System Access		$7.00
Distribution	961@ 0.050510	$48.54
Dist. Tax Reform Credit	961@ 0.003000-	$2.88-
Energy Efficiency	961@ 0.002963	$2.85
Power Plant Securitization	961@ 0.001144	$1.10
Low-Income Assist Fund		$0.93
Total Electric		**$155.31**

Natural Gas Charges

Customer Charge		$11.75
Gas Distribution	0.7@ 2.959400	$2.07
Gas Distribution	1.3@ 3.003100	$3.90
Tax Reform Credit	0.7@ 0.220600-	$0.15-
Energy Efficiency	2.0@ 0.223800	$0.44
U-18124 IRM Surcharge		$0.23
Gas Cost Recovery	2.0@ 2.984000	$5.97
Total Natural Gas		**$24.21**

Total Electric and Natural Gas Charges	$179.52
State Sales Tax	$7.14
Total Energy Charges	**$186.66**

Amount Due: **$197.00**
by October 15, 2018

If you pay after the due date, a 2% late payment charge will be added to your next bill.

Account Balance

Last Month's Account Balance	$296.66
Payment on September 13, 2018	$197.00-
Total Energy Charges	$186.66
Current Account Balance	$286.32

Payments applied after Sep 20, 2018 are not included.

Please make any inquiry or complaint about this bill before the due date listed on the front.
Visit **ConsumersEnergy.com/aboutmybill** for details about the above charges.

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Ways to pay your energy bill:

Auto-pay
Checking or savings
Auto-pay
Discover® MasterCard® or Visa® (Eligibility varies)

Same-day payment:
ConsumersEnergy.com
Discover® MasterCard® Visa® or eCheck

Same-day payment:
866 329 9593
Discover® MasterCard® Visa® or eCheck

By mail
Check, money order
Consumers Energy
Payment Center
P.O. Box 740309
Cincinnati, OH 45274-0309

In person
Cash, check, card or money order
Varies by authorized payment location
Fee may apply

*For more information, visit **ConsumersEnergy.com/waystopay***

Appendix B

NREL

NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

4,944 kWh/Year*

System output may range from 4,703 to 5,094 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.55	263	36
February	3.76	339	46
March	4.84	473	64
April	5.27	478	65
May	5.19	477	65
June	5.53	476	65
July	5.87	514	70
August	5.72	504	69
September	5.63	485	66
October	4.03	378	52
November	3.14	303	41
December	2.45	251	34
Annual	4.50	4,941	$ 673

Location and Station Identification

Requested Location	2145 W Barnes Road, Mason, Michigan 48854
Weather Data Source	Lat, Lon: 42.53, -84.42 0.6 mi
Latitude	42.53° N
Longitude	84.42° W

PV System Specifications *(Residential)*

DC System Size	3.8 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	45°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.136 $/kWh

Performance Metrics

Capacity Factor	14.9%

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Caution: Photovoltaic system performance predictions calculated by PVWatts® include many inherent assumptions and uncertainties and do not reflect variations between PV technologies nor site-specific characteristics except as represented by PVWatts® inputs. For example, PV modules with better performance are not differentiated within PVWatts® from lesser performing modules. Both NREL and private companies provide more sophisticated PV modeling tools (such as the System Advisor Model at https://sam.nrel.gov) that allow for more precise and complex modeling of PV systems.

The expected range is based on 30 years of actual weather data at the given location and is intended to provide an indication of the variation you might see. For more information, please refer to this NREL report: The Error Report.

The energy output range is based on analysis of 30 years of historical weather data for nearby , and is intended to provide an indication of the possible interannual variability in generation for a Fixed (open rack) PV system at this location.

RESULTS

9,887 kWh/Year*

System output may range from 9,406 to 10,189 kWh per year near this location.

Month	Solar Radiation (kWh / m^2 / day)	AC Energy (kWh)	Value ($)
January	2.55	527	72
February	3.76	678	92
March	4.84	946	129
April	5.27	957	130
May	5.19	954	130
June	5.53	952	130
July	5.87	1,028	140
August	5.72	1,009	137
September	5.63	971	132
October	4.03	757	103
November	3.14	607	83
December	2.45	502	68
Annual	4.50	9,888	$ 1,346

Location and Station Identification

Requested Location	2145 W Barnes road, Mason, Michigan 48854
Weather Data Source	Lat, Lon: 42.53, -84.42 0.6 mi
Latitude	42.53° N
Longitude	84.42° W

PV System Specifications *(Residential)*

DC System Size	7.6 kW
Module Type	Standard
Array Type	Fixed (open rack)
Array Tilt	45°
Array Azimuth	180°
System Losses	14.08%
Inverter Efficiency	96%
DC to AC Size Ratio	1.2

Economics

Average Retail Electricity Rate	0.136 $/kWh

Performance Metrics

Capacity Factor	14.9%

Appendix C

YGE 60 Cell 40mm SERIES

Powered by YINGLI

YL260P-29b
YL255P-29b
YL250P-29b
YL245P-29b
YL240P-29b
YL235P-29b
YL230P-29b

YINGLI SOLAR OFFICIAL SPONSOR FIFA WORLD CUP Brasil

ABOUT YINGLI GREEN ENERGY

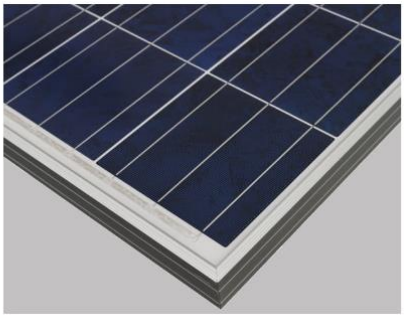
Yingli Green Energy Holding Company Limited (NYSE: YGE) is one of the world's largest fully vertically integrated PV manufacturers, which markets its products under the brand "Yingli Solar". With over 4.5GW of modules installed globally, we are a leading solar energy company built upon proven product reliability and sustainable performance. We are the first renewable energy company and the first Chinese company to sponsor the FIFA World Cup™.

PERFORMANCE

- High efficiency, multicrystalline silicon solar cells with high transmission and textured glass deliver a module efficiency of up to 16.2%, minimizing installation costs and maximizing the kWh output of your system per unit area.
- Tight positive power tolerance of 0W to +5W ensures you receive modules at or above nameplate power and contributes to minimizing module mismatch losses leading to improved system yield.
- Top ranking in the "TÜV Rheinland Energy Yield Test" and the "PHOTON Test" demonstrates high performance and annual energy production.

RELIABILITY

- Tests by independent laboratories prove that Yingli Solar modules:
  - ✓ Fully conform to certification and regulatory standards.
  - ✓ Withstand wind loads of up to 2.4kPa and snow loads of up to 5.4kPa, confirming mechanical stability.
  - ✓ Successfully endure ammonia and salt-mist exposure at the highest severity level, ensuring their performance in adverse conditions.
- Manufacturing facility certified by TÜV Rheinland to ISO 9001:2008, ISO 14001:2004 and BS OHSAS 18001:2007.



WARRANTIES

- 10-year limited product warranty[1].
- Limited power warranty[1]: 10 years at 91.2% of the minimal rated power output, 25 years at 80.7% of the minimal rated power output.

[1]In compliance with our Warranty Terms and Conditions.

QUALIFICATIONS & CERTIFICATES

IEC 61215, IEC 61730, MCS, CE, ISO 9001:2008, ISO 14001:2004, BS OHSAS 18001:2007, SA 8000, PV Cycle

APPROVED PRODUCT CE CERT PV CYCLE

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