Solar Power in Champaign County on Homes, Churches, and on the Ground

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Introduction

Champaign Urbana is a local hot-spot with recent solar activity in a state that is more known for corn and soybeans than renewable energy. Solar panels are appearing on houses, businesses, churches, and in fields across the area. The dramatic drop in material and installed costs, along with overlapping federal and local incentives, make this a boom time for solar in Illinois. The 2016 IL Future Energy Jobs Act revamps the renewable energy credit market auction, continues the requirement for utilities to offer net metering, and opens possibilities for community solar farms. Recent developments in community solar farms are an exciting new direction that solar power is taking in Illinois.

Solar on rooftops can make good environmental and economic sense, but is limited by how few rooftops are well suited in an urban area with trees and other buildings. Building solar farms on the ground is generally less expensive and can have added environmental benefits compared to standard row crops. The land area required for solar farms is a very small part of our agricultural landscape and even in prime farming areas like Illinois will have minimal impact on farming but potentially be very beneficial to the environment.

This report is a summary of my work with solar power in Champaign-Urbana since 2016. This involved installing solar on the roof of the Urbana-Champaign Unitarian Universalist Church, an installation at my home, my educational presentations with the UC Solar group-buy educational programs, and advocating for community solar farms and pollinator support in Champaign County.

Contents

List of Figures

Local Church Solar History

Local houses of worship offer a unique opportunity to be pioneers in solar power, as the price has started to become affordable in recent years. Individuals who may not have a good solar resource on their home roof might be interested in donating money for solar at their church to benefit the group and the environment. In 2008, before solar PV prices were affordable, Faith United Methodist in Champaign put up solar thermal tubes to offset their kitchen hot water heater usage. This was a small part of their overall energy use for the church, but acted as a way for local groups to see first-hand what solar power looks like. A local interfaith environmental religious group, Faith in Place, has been leading efforts to get houses of worship involved with solar and energy efficiency by hosting workshops and giving expert advice.

In 2014, First Mennonite of Urbana put on a small 9kW solar PV array. In 2017, the Unitarian Universalist Church of Urbana-Champaign put up a large 24kW array that will offset 70% of their electricity use. This is one of the first churches in the region to utilize a power purchase agreement (PPA) to pay for the system over time. The PPA is owned and operated by a LLC which can utilize the federal tax credits. McKinley Foundation on the U of I campus followed, with a similar sized system and PPA structure. Since that time, more than a dozen churches in the state have setup similar solar rooftops.[1]

Unitarian Universalist Church of Urbana-Champaign

In 2016, the Unitarian Universalist Church of Urbana-Champaign (UUCUC) was looking to replace the flat membrane roof over the 1960 education wing. As the head of the GreenUU environmental group and co-leader of the Property committee, I was in a place to be able to be a champion for adding solar to the new roof project. This project originated through a workshop with Faith in Place, where Cindy Shepherd and Jason Hawksworth presented how the PPA scenario could work for houses of worship. Of the six congregations in attendance, four received solar bids, and at least two of them installed systems in 2017-2018.

UUCUC had a series of meetings with bids from solar contractors, including StraightUp Solar of Bloomington, the vendor for the 2016 CU Solar group-buy program, New Prairie Solar of Urbana, and Hawk Energy Solutions of Peoria. Hawk Energy Solutions was selected due to their experience working with non-profit groups and their proposal of a power purchase agreement.

Figure 1: Panoramic view of the solar racking system on the new white roof of UUCUC

[1] https://www.faithinplace.org/program-implemented/solar-panels

Figure 2: Panoramic view of the final install

The 24-kW solar system was completed and energized on March 29, 2017.[2] In the first year, it generated about 27,000 kWh / 39,100 kWh used, or 69%. This saved about $1,100 and is the equivalent of planting 488 trees. Once the system is paid off, the yearly savings will be closer to $2,200. The array was designed and installed by Hawk Energy Solutions and Ruyle Mechanical of Peoria. The church purchases all the electricity generated through a PPA. Hawk-Attollo LLC is the corporation that operates and maintains the system through the PPA. This PPA allows the church to pay over time while using the 30% Federal tax credit, receiving accelerated depreciation, and participating in the Illinois Solar Renewable Energy Credit auction.

In the UUCUC installation, 81 Silfab 300W Monocrystaline panels with Enphase micro-inverters cover about 75% of the flat roof. The panels and micro-inverters have a production warranty of 25 years where they will still output 80% of their rated power. There was a comparison and discussion regarding more traditional DC wired system with central inverters versus and micro-inverters. At the time, micro-inverters were the better option for reporting data from each panel, and generally do have a longer warranty.

The total price for the solar install would have been $86,000, or $3.44/watt, but the price for the PPA is reduced by the federal 30% tax rebate, and the sale of the first five years of Renewable Energy Credits (RECs). Through the PPA, the church initially buys electricity from the solar array at $0.04/kWh (half the total Ameren supply+delivery rate of $0.08/kWh), with a 2% escalation per year to result in $0.053/kWh in year 15 if the system was not bought out before then. The church has the option to buy out the solar contract in year 7 and the savings from the system is expected to pay for itself around year 12. The church raised $20,000 as a down payment, has an expected buyout cost of $10,000, and will pay an estimated $8,300 in purchased electricity over 6 years. When factoring in the church's investments of about $38,300 over 6 years, this comes to $1.52/Watt after incentives. People were encouraged to donate to the roof+solar campaign and the results were tracked on a poster board with 81 little solar panel stickers. Several different PPA scenarios were compared during the selection process.

Option	PPA Prepay	PPA Rate	PPA Costs	PPA Buyout	Total Investment $'s
1	$15,000	$0.08	$16,023	$10,000	$41,023
2	$17,000	$0.07	$13,019	$10,000	$40,019
3	$20,000	$0.04	$8,192	$10,000	$38,192
4	$12,000	$0.11	$21,503	$10,000	$43,503

Table 1: PPA Options considered by the selection committee

[2] UUCUC Solar Blog: https://uucuc.org/green-uu-solar-project

Over 25 years, if this system generates 800,000 kWh, the result will be a levalized cost of electricity of $0.048/kWh. This is like paying upfront for the next 25 years of electricity and locking in at a rate that is almost half of what they pay now. Over the life of the system, the electricity savings, including a 2% escalator, is estimated to be $49,000, or $1,961/yr. Without incentives, this would have resulted in a price of $0.1075/kWh. The roughly three year lifetime production of the system is 73,360 kWh, or 27,900 kWh/yr. This is equivalent to planting 1,326 trees or offsetting 91 flights from New York to California.

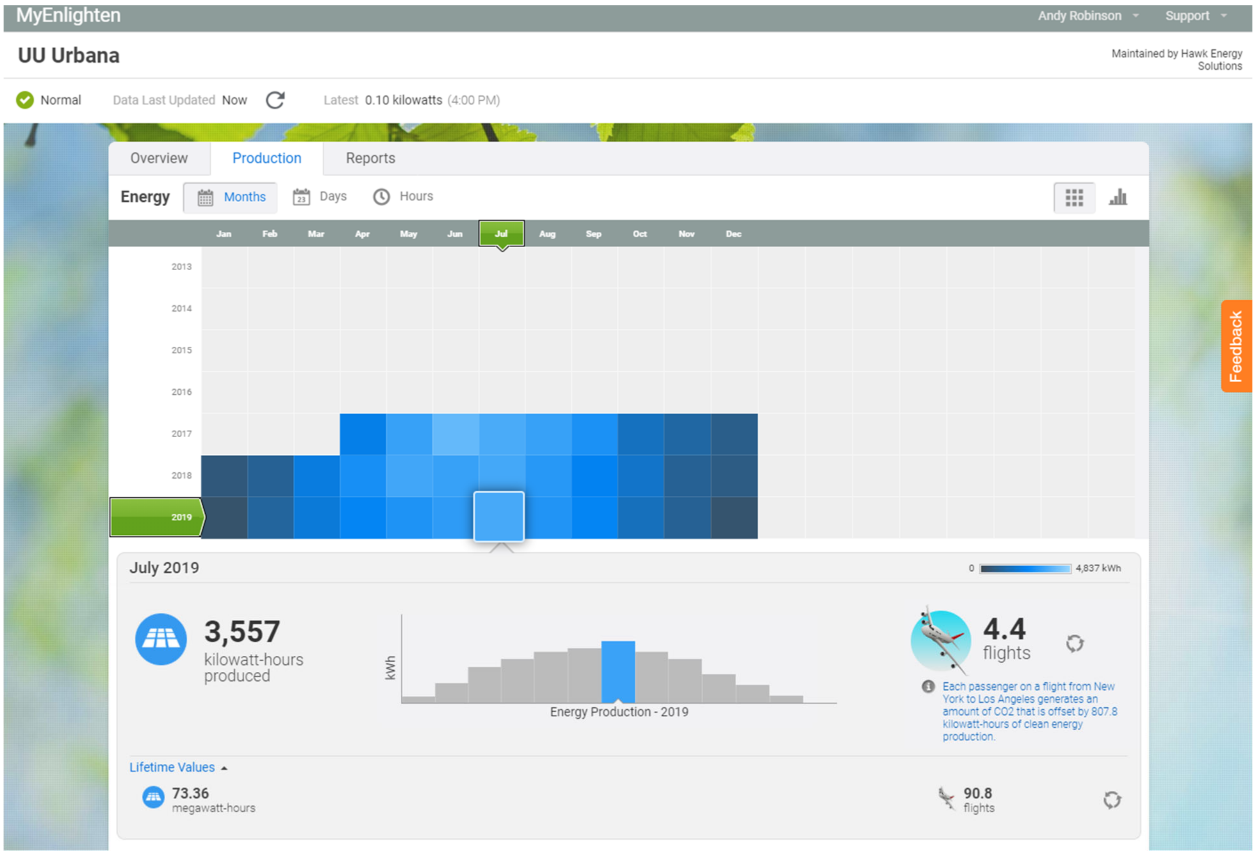


Figure 3: Enphase online data portal

In conjunction with this project, the church installed a new white membrane over the old leaking black rubber roof. The solar array doesn't penetrate the membrane, but instead rests on metal feet on rubber mats held down by concrete blocks. The weight load of the panels and racking feet is minimal, but the weight of the concrete block ballast was a limitation.

On a pitched roof, the typical solar angle for this latitude is about 30-40deg, but that higher angle on a flat roof would have to withstand a higher wind load and also results in panels shading the neighboring rows. This requires more weighted ballast blocks and also reduces the number of panels on the roof due to increased row spacing. The racking system that was chosen had options of 10deg and 20deg. The production estimates showed that there was about a 4% reduction in yearly total electricity production to angle the panels at 10deg compared to 20deg and a 10% reduction compared to 40deg. This reduction in output was lessened because two more rows could be added to the roof, bringing the total system up to 81 panels. The panels were place on the northern ¾ of the roof area to avoid the shading from a neighboring birch tree. This was modeled in Sketchup using Google Earth satellite data and verified by matching shadows to the time of year in the imagery.

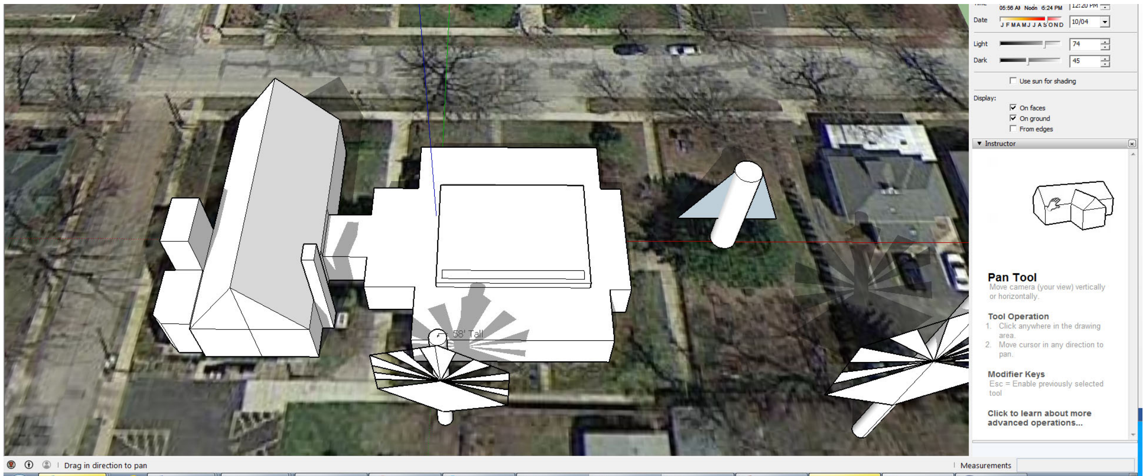


Figure 4: Sketchup model used for estimating neighboring tree shading

Since Green Street is in a special business/residential exclusion zone, it had to go through a review by the Urbana zoning board. The zoning board had concerns that the higher 20deg angle would be more visible from the street and approved the lower 10deg angle based on a requirement that no mechanical equipment be visible from the street. This compromise was accepted, as the lower ballast weight did not require a full engineering analysis of the roof's structural beams and instead could be approved based on a simple visual inspection.

An integral part of this system is the real-time energy monitor on the solar production and on the building use.[3] The energy monitor has four sub-meters for the four wings of the church. This shows instantaneously how much energy is saved by turning lights off, and being able to check whether the air conditioning or dehumidifiers are left running all night. Several middle school aged classes have been shown how to log into the system using a tablet, and then do experiments with turning on/off lights and fans, so the system serves an educational role, as well.

[3] UUCUC solar and building real-time meter: http://egauge34171.egaug.es/58863/

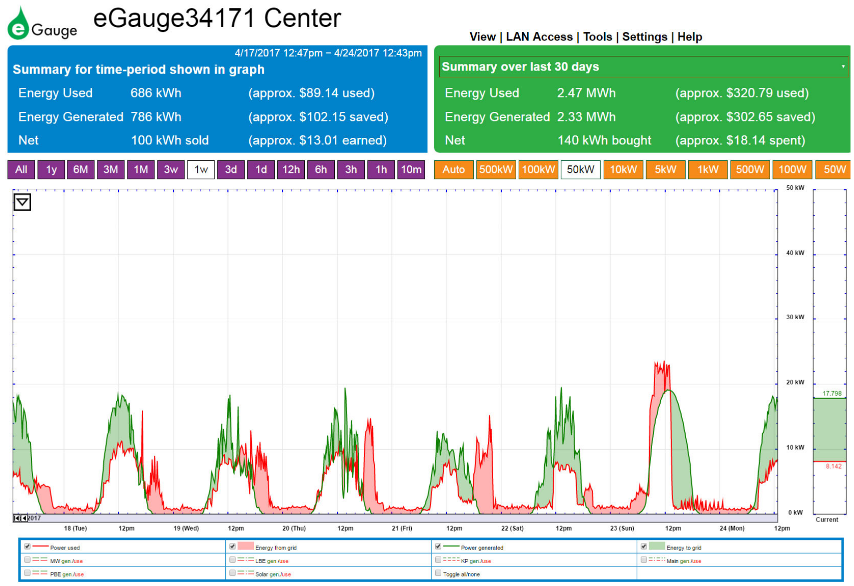


Figure 5: One week of solar production (green) and building use (red).

One question that arose in the planning process was if we should also add battery backup. The following figure shows the cumulative cost of electricity purchased from the grid (red line) increasing at a steady 2%, and the cumulative cost of the solar array (blue line). The solar array has an initial cost of $20,000, the $10,000 buyout in year 7, and then no yearly cost until an estimated $18,000 of maintenance at year 25. This includes the potential cost to remove the panels for roofing maintenance, and possibly new inverters. The upper green line is the price of the solar PPA with the added cost of an estimated 121 kWh battery system that would allow the facility to be completely off-grid for 24hrs (estimated at $55k in 2017). This is clearly not an option based on economics alone and it would be necessary to have a much higher price of electricity, lower cost batteries, or to put a very large value on the price of backup battery storage.

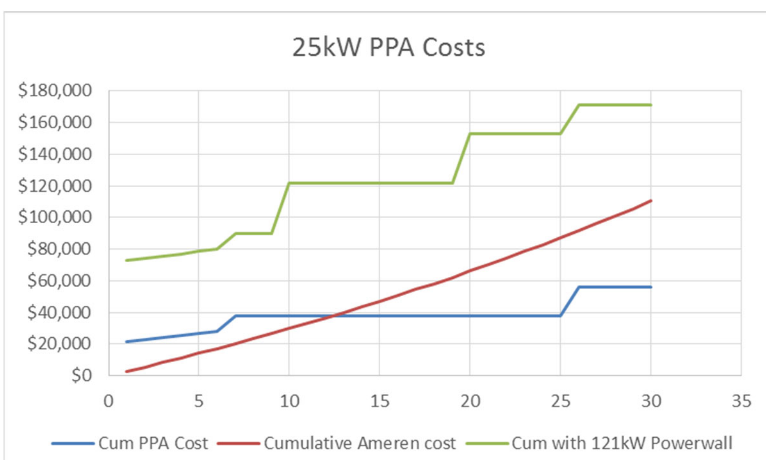


Figure 6: Costs of electricity, solar, and battery storage

Solar Urbana-Champaign Group-Buy Program and Educational Talks

I have been the educational coordinator presenting the Solar Power Hour informational talks for the SolarUC 2, 3, and 4 programs in the summers of 2017-2019. The Solar Urbana-Champaign group-buy program is a DOE Sun-Shot modeled program to teach homeowners about solar power, financing, and to lower the cost of solar ownership through bulk pricing. It encourages homes and businesses to take advantage of utility net metering and overlapping federal tax and local renewable energy credits. These overlapping incentives were possibly going to end at the end of 2017, but the federal incentives were renewed. The federal credit currently ramps down to 26% in 2020, 20% in 2021 and then 0% for residences and 20% for businesses after that. There are current federal legislation proposals about extending these incentives based on getting the entire grid to 25% renewable instead of having a cutoff year.

The Illinois Solar Renewable Energy Credits (SRECs) are currently paying for about 40% of the system cost. This is calculated on a production estimate for 15 years of renewable energy production and is paid upfront to the property owner. These renewable energy systems are then counted toward the state's goal of getting 25% renewable energy production by 2025. The funds for this program come from a renewable energy fee collected on Ameren and ComEd bills. This is typically about $1/month on a residential bill and is the cost of getting our grid to 25% renewable. This cost for the first 25% is likely to be higher than the next 25% due to cost efficiencies of maturing technology. However, if battery and other energy storage are required with future higher renewable energy penetrations, that cost may have to be re-evaluated.

The Midwest Renewable Energy Association administers the Solar UC program with an advisory board of local members including Scott Tess, the Sustainability Coordinator with City of Urbana. In 2019, the program chose New Prairie Construction in Urbana as the prime contractor for the program based on their experience, qualifications, and price. The educational power hours ran May-Aug 2019 and site assessments were free for anyone in the county with fixed program pricing. Installations are planned to be completed before Dec 31, 2019 in order for participants to qualify for the full 30% federal tax credit.

"The 2018 group buy resulted in over 60 installations of solar on homes and commercial properties all over Champaign County," said Scott Tess, Environmental Sustainability Manager for the City of Urbana. "It was one of the most successful programs of its kind in the region. We wanted to build upon the strong interest that we know exists here."[4]

Since the Solar Urbana-Champaign programs began in 2015, 226 properties have added 1,957 kW of solar in Champaign and Piatt Counties. There have been over 1,200 participants at educational sessions who have seen the real-world examples of how solar power can offset their carbon footprint, and be a good financial decision.

[4] http://solarurbanachampaign.com

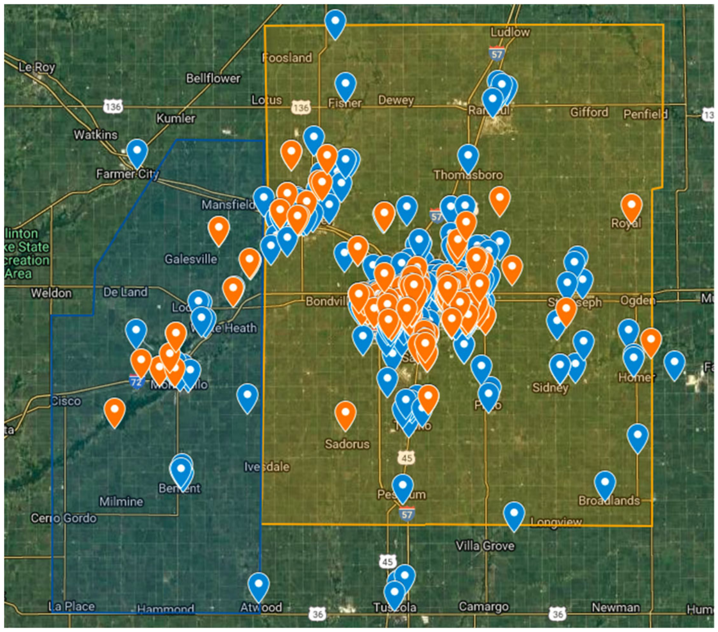


Figure 7: Map of assessments (blue) and installs (orange) from 2016-2018

Residential Solar

New Prairie Solar got the bid this year and the base program price was $2.99/Watt. The typical panels are high efficiency 300W and the inverters are SolarEdge with DC optimizers so each panel can operate independently if they are shaded or have a warranty issue. There is a 10-year warranty on the install, 12 on the inverters, and 25-year production output guarantee on the panels.

For incentives, there is the federal tax credit of 30% that starts ramping down after 2019. Businesses can even take accelerated depreciation on top of that if they have enough tax liability.

There is an additional local market-based incentive that is worth about 20-30% of the cost of the system. This is from selling the first 5-15 years of Renewable Energy Credits (RECs) through the Illinois Commerce Commission (ICC). Note the ICC runs the auction, but the money is collected through the two main Investor Owned Utilities, ComEd and Ameren. The goal of the program is to get the grid to 25% renewable energy by 2025. The price of the RECs that New Prairie won in 2017 was $155/MWh for five years. For 2018 and 2019, that went down to a fixed price of $82/MWh for 15 years, but the overall incentive was greater and it is paid out in the first year. In my home's install, that would have increased my incentive from $8k to $13k and lowered my simple payback from 12 to 7 years.

Ameren gives credit for any excess electricity produced (called net metering) and that essentially makes the meter spin backwards (like rollover minutes). Net metering allows customers to feed excess electricity back into the grid, thereby not requiring costly batteries. Those credits zero out over the course of a year, so it's not financially advantageous for homeowners to produce more than 100% of what they use in a year. Any excess generation credit zeros out in April, which works well for overproduction during summer, and underproduction during the winter.

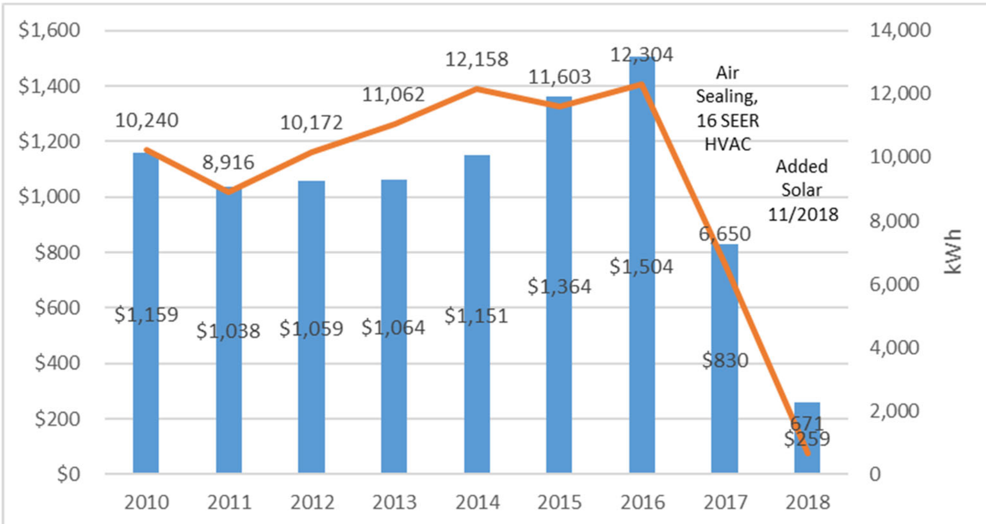
My Home's Solar

In the summer of 2017 we added solar to the roof of our 1921 house. The roof faces east/west, so it seemed at first like there wasn't a good solar option, but initial estimates showed that it would be about a 14-year payback with the group-buy price, the federal tax credit, and the SREC incentives. In its first year it generated 8,800 kWh in 2018 and my house used 9,200 kWh, so that was within $50 of the estimate. In 2017 my house only used about 7,000 kWh, likely due to a cooler summer. Completely covering the east and west roof surfaces in 36 QCell 300W cells results in 10.8kWdc of panels. There will never be a time when both the east and west faces are in peak sun, so the inverter was sized at 7.6kW AC with DC power optimizers on the panels. This results in an average unit power production of either, 833 kWh/kW, or 1,184 kWh/kW. Typical output for an ideal rooftop south-facing system is 1,200-1,300 kWh/kW.

Figure 8: Robinson residence

In the 2017 program, typical residential base prices were $2.99/W and Commercial 25kW systems were quoted at $2.55/W. My 10.8kWdc system has an initial cost of $2.77/Watt because it was over a 10kW threshold. This system cost $30k, and I got back $9k in a tax rebate, and about $8k in selling my RECs paid out quarterly over 5 years. Then my net cost of $13k will take about 12-14 years to pay back if the system offsets about $1k/yr on my power bill. That should offset around 90% of my electricity. Most systems pay back between 7-12 years, but my site is non-ideal since my roof faces E/W and I have a large tree to the west. Several years ago the cost of the solar panels was so high that people would not typically put them on a house with anything but an ideal south-facing roof. Now that costs have come down dramatically, the 20% reduction that an E/W roof gets is not as big of a problem.

The annual and monthly billed kWh and cost figures illustrate how much the electric bill has been reduced. There was some increase in 2015 and 2016, likely due to my wife working from a home-based office, which adds air conditioning cost and electric heating in the winter. The dramatic reduction in 2017 only has two months of winter solar output, but did include a new 16 SEER air conditioning system, basement air sealing, and attic insulation. The 2017 summer was also milder than others so that can compound the differences. The net result in 2018 is that the total electric bill in 2018 was $259 and that is a savings of $750-1,200 compared to previous years.



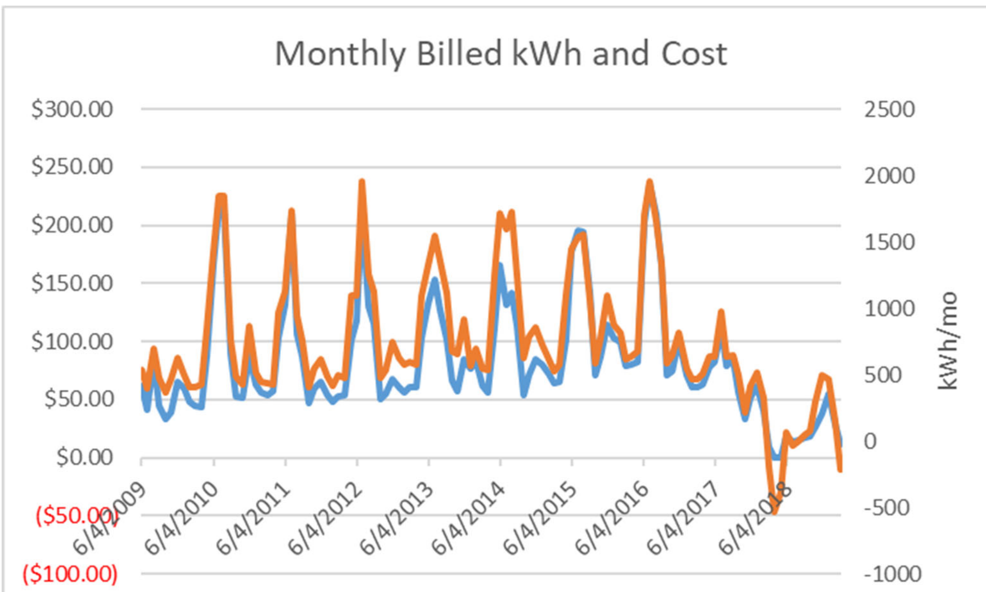


Figure 9: Billed kWh and cost

The months of April and May 2018 had enough overproduction that they resulted in a $0 bill. This is unique to the Power Smart Pricing program, as the typical Ameren Net Metering agreement will still result in a $13-15 monthly service fee. Upon detailed inspection, this seems less like annual net-metering (with an April zero), but more like monthly net metering. This could be a disadvantage for summer months with lots of excess generation.

The scatter plot in Figure 10shows that in months that netted 0 kWh, I still paid about $15. On the right side, the slope is about $0.09/kWh, but the four months where I over-generated, the slope is about $0.033/kWh, indicating that I was being paid at a reduced generation rate, not the full net meter rate. It's possible that the month that generated -536 kWh should have paid me about $5-10, but this doesn't seem like too big of an issue. Another issue is that it does not appear that excess generation is being paid at a higher summer peak time of use (TOU) rate, which would likely have made this program more advantageous.

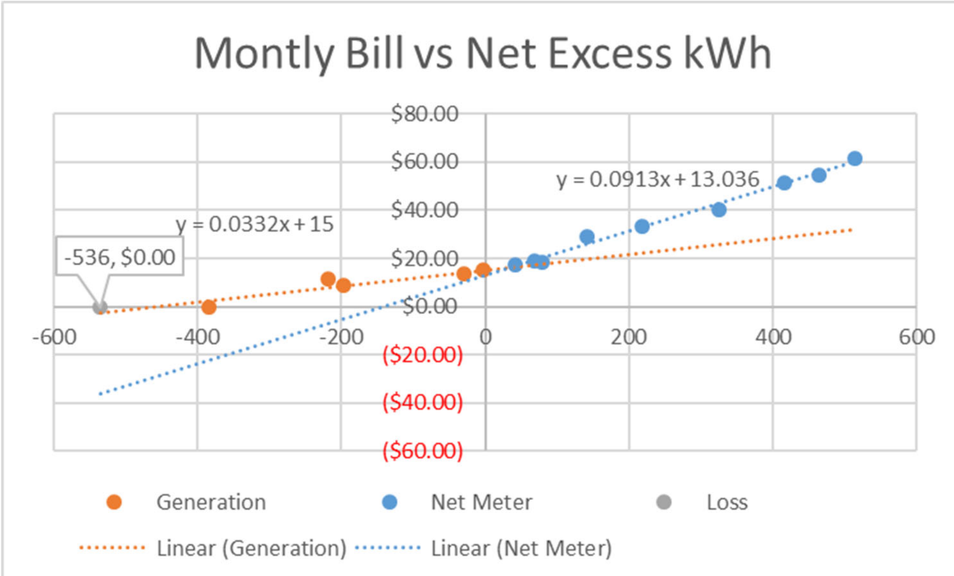


Figure 10: Illustration of potential monthly net metering

The SolarEdge central inverter reports data for each individual panel to aid in reporting to the state and identifying warranty issues with panels or power optimizers.[5] Figure 11 shows the effect of a large tree west of the house, and also the chimney shading one of the center panels. Traditional central string inverters have all panels in a string wired in series, and if one panel is shaded or fails, the entire string goes down. An advantage of the DC power optimizers is that if one panel is shaded, the entire string is not reduced. This is particularly helpful for residential applications with trees and obstructions.

[5] https://monitoringpublic.solaredge.com/solaredge-web/p/site/public?name=Robinson&locale=en_US#/dashboard

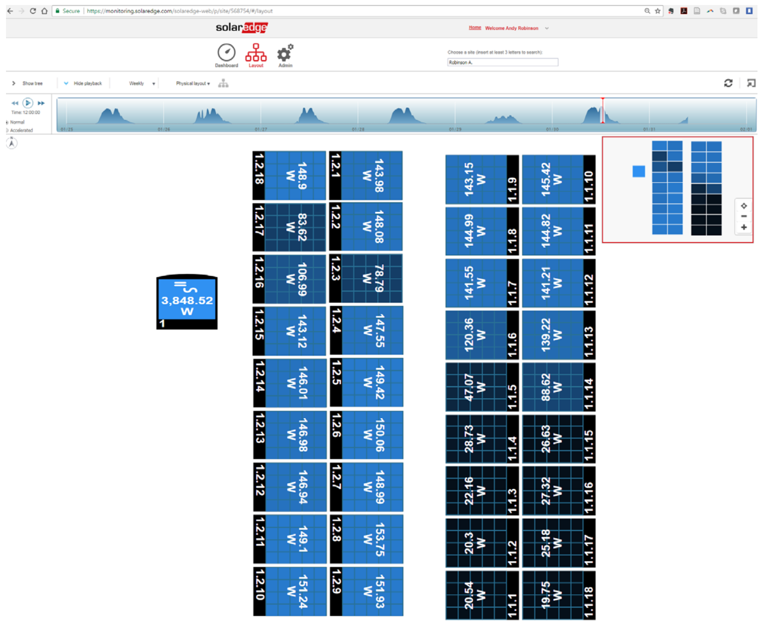


Figure 11: Solar Edge online monitor

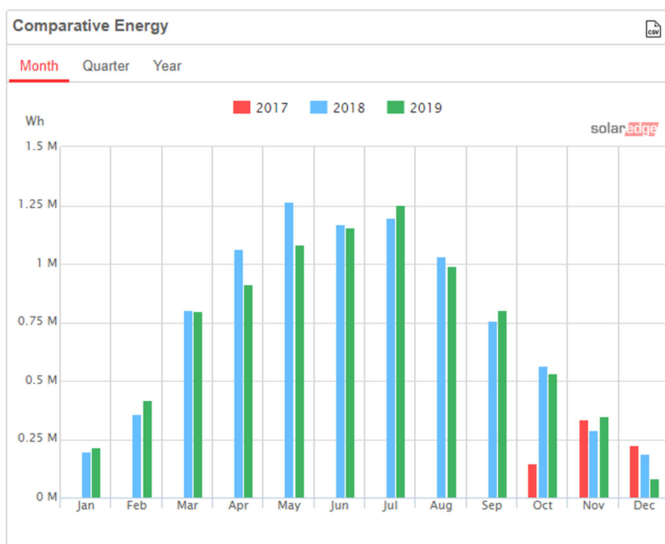


Figure 12: Monthly solar production

I also purchased the Sense home energy monitor that cost $300 and reports real-time data on my phone and has learning capabilities to identify appliances and give energy summaries. One interesting discover is that I have a chest freezer with a compressor that never turns off, costing over $100/yr, although the energy star label shows it only using $23. It is also valuable to be able to see the data from intermittent loads like the air conditioning, which is showing a total annual use of $193/yr.

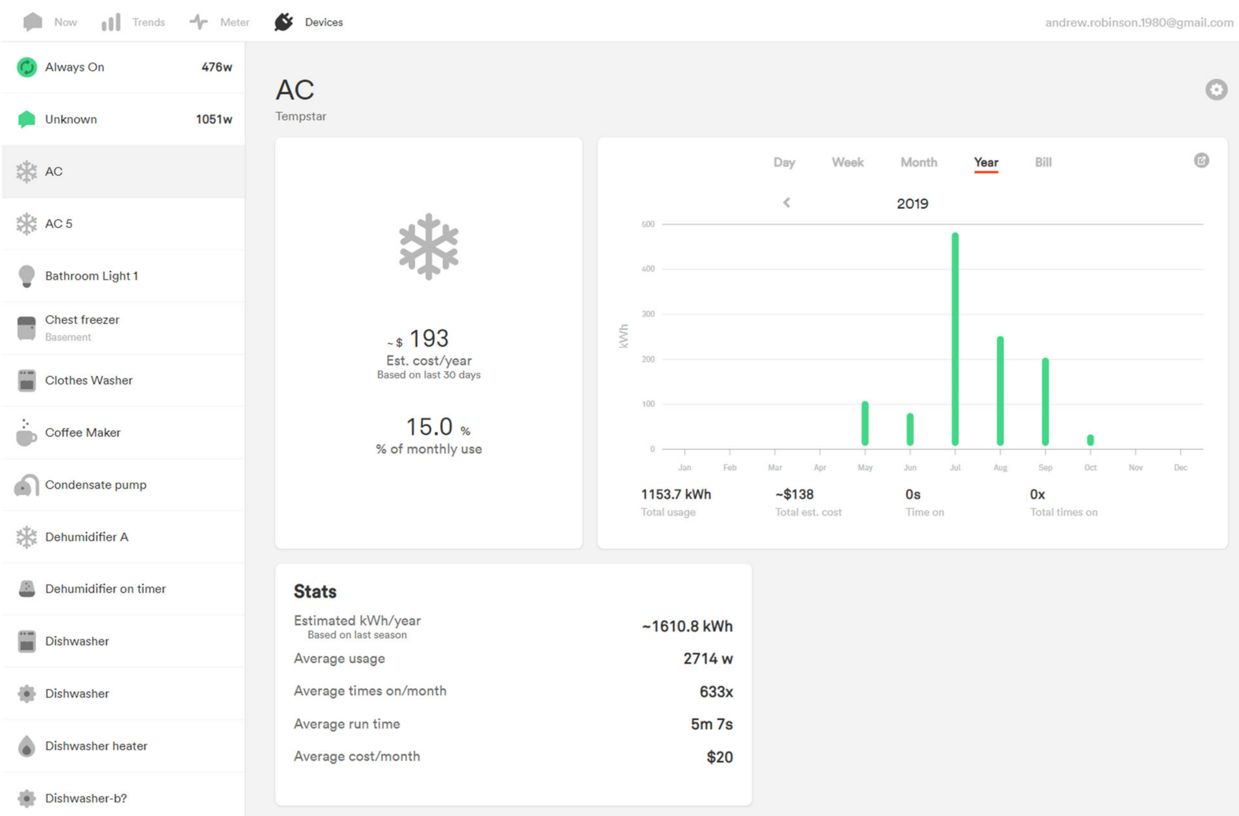


Figure 13: Domestic air conditioning use calculation

The data from Sense is the only way to look at the total kWh used, as the Ameren utility meter only sees the instantaneous net of the used and produced. This bar graph comparison view shows a 2019 use of 9,373kWh, and solar production of 8,460 kWh or 90% as of mid-December. 2018 data shows 8760/9402 kWh = 93% from solar.

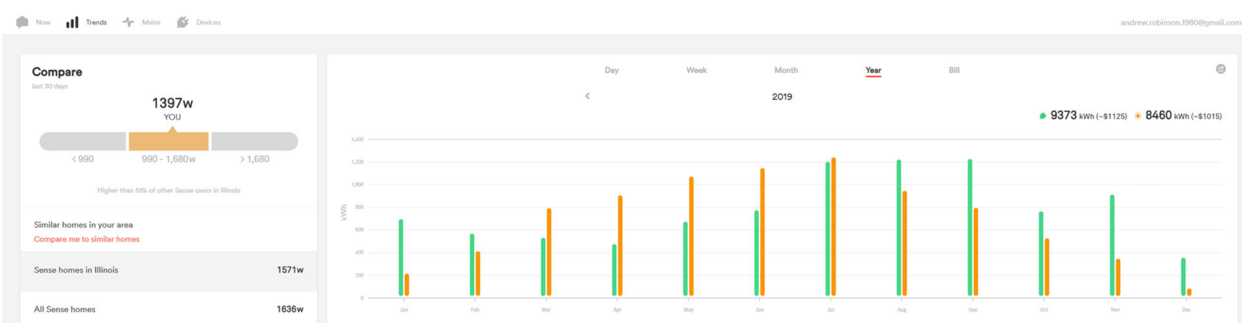


Figure 14: Sense reporting 2019 use of 9,373kWh, and solar production of 8,460 kWh

The real-time view allows for pinch and zoom data analysis and long-term trends at a glance. This data from early October shows air conditioning (red spikes left), solar generation (orange peaks), and electric vehicle trickle charging at 1.4kW during the night (middle red).

Figure 15: Sense Power Monitor real-time view

In October 2019 I purchased a Tesla Model 3 with a 75kWh battery pack and rated 250-320 miles of range. At an average of 340 Wh/mile, 12,000 miles will use 4,080 kWh. At the average rate of $0.091/kWh, this would cost $373/yr. However, I also participate in the Ameren Real Time Pricing program which has a variable rate of electricity with rates at night averaging $0.03 less than in the daytime. Charging at night at $0.06/kWh, results in a fuel cost of $245/yr. This compares to the gas car I was driving which cost about $1,200/yr at $2.50/gal and 25 mpg. The feeling of driving with power that was produced from our own roof (or net produced during the day and wind or nuclear at night), is very empowering. The knowledge of environmental benefit and the cost savings help me want to switch from airline travel to road-trip even if it means the trip will have to add a 20min charging stop every 2-3 hours.

I will be very interested if in the future, Tesla allows for vehicle to grid (V2G) energy transfer. This would allow the car to be charged at night, but then supply to the grid during the day. If the day/night cost spread were high enough or if peak demand or stability were worth more, this might make economic sense. This would be offset by wear and tear cost on the battery and the cost to deploy V2G charging stations at scale in parking lots.

UI Solar Farms

In 2015 the University's built their first 4.68 MW solar farm on Windsor near First St. That Solar Farm produced about 6,900 MWh/yr average over the past four years, or about 2% of the campus' electricity. The highest production year was 2015 with 7,199 MWh and the lowest was 2016 with 6,550 MWh. This yearly variation is expected and results in a production land efficiency of about 330 MWh/acre. The 18,867 fixed-tilt panels cover 20.8 acres and was the largest on-campus solar farm in the country at the time of construction. However, now it is rivaled by other university solar farms such as Penn State's 2MW onsite and proposed 70 MW solar farm, although that is not close to their campus and is not directly connected to their electrical grid. Penn State has also been having workshops with local farmers and stakeholders about ways that "Solar Farming" can be integrated into the local economy and ways to use the ground under the panels for agriculture. This would be an interesting thing for the UI farm to actively pursue given the land-grant history, and proximity with the South Farms energy and agricultural research. Solar farms offer a unique opportunity for farmers to both reduce their operational costs, and diversity their income streams from their land.

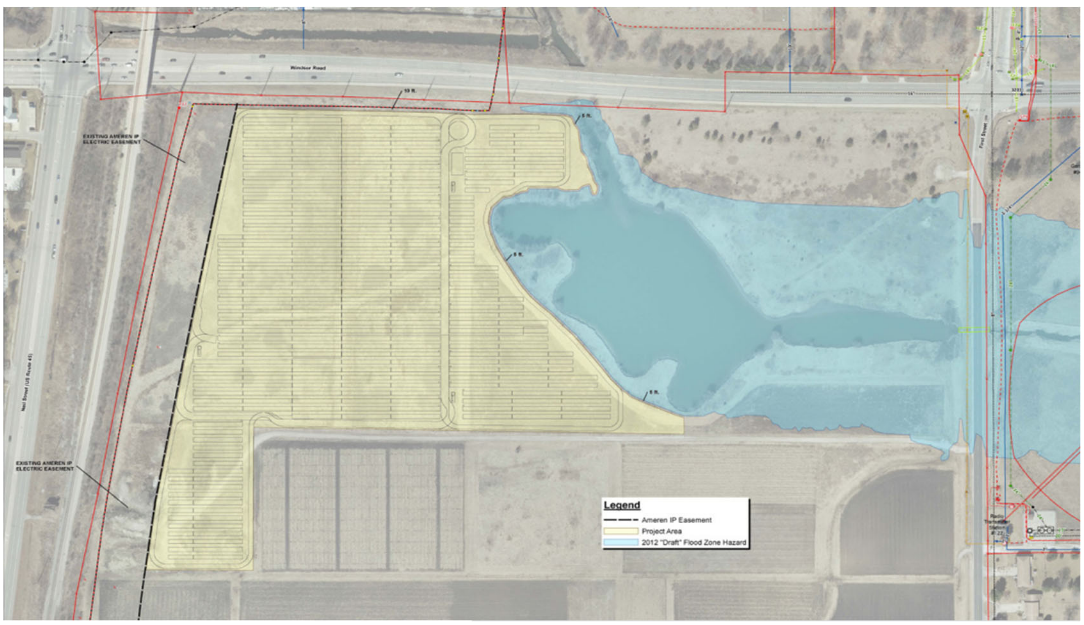


Figure 16: UI Solar Farm 1.0

The UI has a 10-year power purchase agreement with the developer, Phoenix Solar, LLC., to deliver all electricity produced directly to the campus grid; the University will own all the associated Renewable Energy Certificates (RECs) and emission credits. The University has a renewable energy goal of 25,000 MWh by 2025. This includes power purchase agreements with a local wind farm, plans for solar arrays on suitable campus buildings, parking garages, and another solar farm. A power purchase agreement with the Rail Splitter Wind Farm north of Lincoln, IL provides an additional 7% of campus needs from a local wind farm. Current campus solar installations include rooftop solar panels at the Wassaja Residence Hall, the Business Instructional Facility, and Electrical Engineering Building, ground mounted panels at the Building Research Council and Allerton Park, and solar thermal evacuated tubes helping to heat the pool at ARC.

The UI Solar Farm 2.0 was approved in 2019 and will have a peak power of 12.1 MWdc over 54 acres. It will produce about 20,000 MWh per year and is located south of the existing solar farm at First St and

Old Church. The panels in this farm are going to be on single axis trackers oriented N/S so they will face the sun in the morning, be horizontal at noon, and then face the sun in the evening. This arrangement results in somewhat more daily production, although a slightly lower peak output at noon. The added cost for the tracker system is made up for in increased production and this system is expected to generate about 370 MWh/acre.

Figure 17: UI Solar Farm 2.0

The farm is being built and operated by Sol Systems, LLC for a 20-year, $20.1m contract with a PPA arrangement. The University's energy purchasing arm, Prairieland Energy, Inc. will buy the energy at a fixed rate of $0.0455/kWh during that period. The energy purchase price in the first year is about $920,000, which is estimated to be about $300,000 cheaper than purchasing from the grid when including peak demand and transmission costs. The University will retain the renewable energy credits, which is a unique difference with both solar farms compared to other solar installations throughout the state which typically sell the RECs to become part of the State's renewable energy portfolio.

One lesson learned from the original solar farm is that weeds will still grow under solar panels. A common complaint from observers in the first summer of operation was that the vines and grass were growing too high and looked unsightly. The anecdotal comment from Morgan White on her monthly solar farm tour was that the management company was based in Arizona and used to solar farms in dry climates where the grass and weeds didn't require mowing more than once a year. Some maintenance changes were made in that first year to accommodate Illinois growing conditions. The press release for the project states that the new solar farm will have pollinator-friendly plantings under the panels and a native prairie planting along the edge.

The site will also feature a landscaped buffer between Solar Farm 2.0 and the Village of Savoy, along Curtis Road. The areas under the panels will be planted and maintained as a pollinator habitat to enhance ecosystems for local and migratory birds and insects, including butterflies and bees. When completed, this site will serve as a demonstration for pollinator-friendly solar arrays, following the requirements of the Pollinator Friendly Solar Site Act (Illinois Pub. Act 100-1022).

I have been participating in local solar farm landscaping webinars and phone calls in addition to presentations at the Champaign County Zoning meetings. One industry-recommended practice for naturalized plantings under solar farms is to raise the panels 36" to allow plants to grow higher between mowing and reduce the risk that a mower will run into the panels.[6] Reducing mowing time and fuel is a good way to reduce maintenance costs and increase the environmental benefits.

According to the official UI project press release[7], and UI Landscape Architect Brent Lewis, "We are intertwining nature and this utility project in a way that creates a truly multifunctional landscape; enhancing the aesthetics of this corridor, providing habitat for wildlife and reducing our reliance on fossil fuels. Campus landscapes in the future will borrow heavily from this model."

The recent Dailily Illini article reinforces this commitment to pollinator friendly plantings:

"Sol Systems engineers are designing a multifunctional landscape for the project in tune with the designation as a bee-friendly campus environment the University earned from Bee Campus USA, with features including a pollinator habitat that will be planted in the areas under the panels to enhance ecosystems for local and migratory birds and insects, including bees and butterflies."

"Andrew Gilligan, vice president of Sol Customer Solutions, said in a press release that the project will have yet another environmental benefit some may not expect. "This project is noteworthy – not only due to the considerable savings and how significantly it advances the overall sustainability goals for the University but also because it was designed to provide habitat for wildlife," Gilligan said.[8]

[6] https://cecco.com/pollinators/
[7] https://www.fs.illinois.edu/resources/newsroom/2019/09/19/solar-farm-2.0-to-nearly-triple-on-campus-renewable-energy
[8] https://dailyillini.com/news/2019/12/11/university-finalizes-agreement-with-energy-company-for-newest-solar-farm/

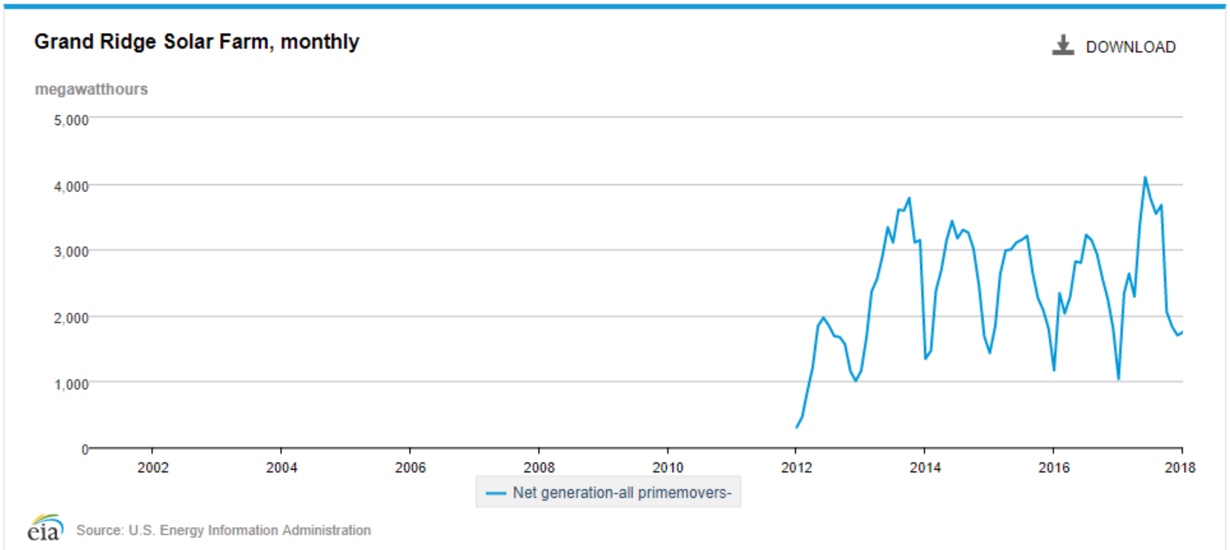
Grand Ridge Solar Farm

For comparison, one of the state's first large solar farms installed in 2012 is the 20MW Grand Ridge solar farm in LaSalle County, near Streator IL. The site consists of twenty, 1MW inverters and 155,000 PV panels by General Electric, covering 122 acres.[9] In addition, there are nearby wind farms operated by the same company, Inveregy. In 2015, this solar/wind farm installed battery storage rated at 31.5 MW peak and 12.2 MWh, although there is not good price or technology information about the specifics of the batteries.[10] Recently, batteries are being installed at about 10-20% of the total project size to help with short-term power fluctuations that result from renewable generation sources that don't have spinning generators (which aid phase stability of the grid).

Figure 18: LaSalle Grand Ridge solar farm

There is good historic production data for from the Energy Information Administration for this solar site. The monthly data shows solar output and the 3x variation of 3,000 mWh in the summer to 1,000 mWh in the winter. The annual data from this farm shows the average of 30,000 MWh production from this 122 acre farm results in 245 MWh/acre. At 330 MWh/acre and 370 MWh/acre, the respective UI Solar Farm 1.0 and proposed UI Solar Farm 2.0 are increasingly more effective and efficient at generating electricity per acre and at a cost that is competitive rate to traditional sources. This is very hopeful for the future expansion of solar farms at a larger scale.

[9] https://iea.net/Projects/Grand-Ridge-Solar
[10] https://invenergyllc.com/what-we-do/advanced-energy-storage



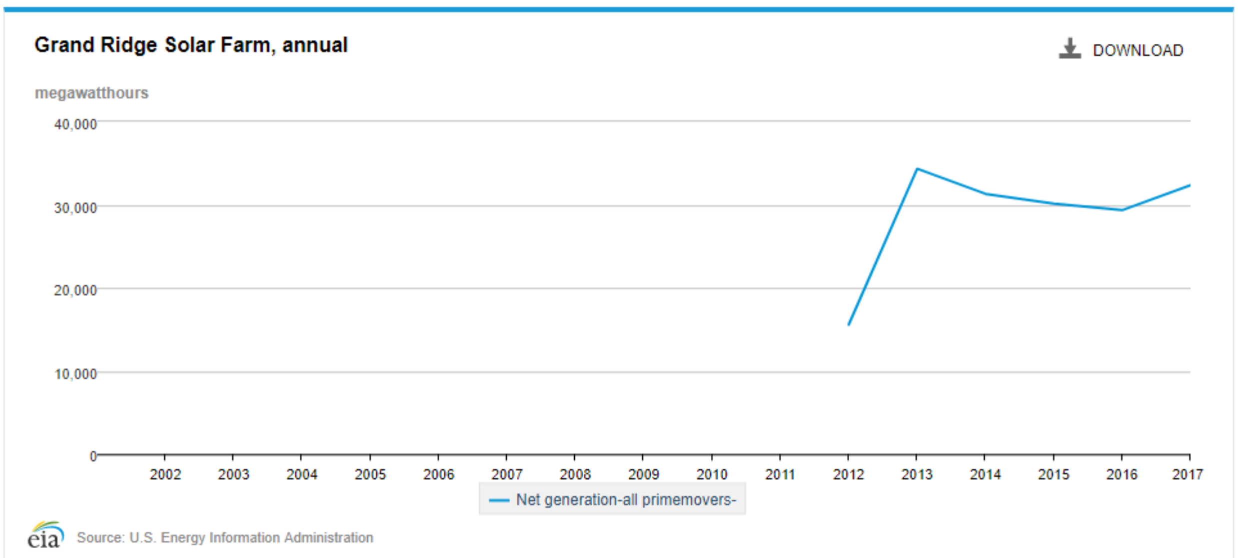


Figure 19: Monthly and annual production

Community Solar Farms

The Future Energy Jobs Act that passed in 2016 included language for community-scale solar farms using a type of virtual net-metering. This would be an arrangement where renters or homeowners with shaded roofs can sign a long-term agreement to buy their electricity from a nearby solar farm. Some discussions locally have included considering using one of the town's old landfills or other brownfield spaces. In fall 2019, Urbana was awarded two 20MW community solar farms to be built at no cost on the old Urbana landfill with funding from the Solar for All program. This program is a community solar program where homes and organizations who are income qualified can purchase their electricity at half the Ameren rate, or $0.04/kWh. More details of these programs are being developed in fall of 2019 and can be found from the Illinois Power Authority.[11]

The land required for solar farms is a typical concern among people in a farming community. This is especially a concern in Central IL where the rich soil from previous glacial flattened swamps and prairie plants results in excellent conditions for farming corn and soybeans. This results in farmland that is very productive and that sells for a high price, averaging $10,000/acre.[12] However, farming corn and soybeans is dependent on the international commodity price of the product, recent tariff disputes, and the input cost of equipment, fuel, fertilizer, and pesticides. The result is that while good row crop farmland can produce $600/acre, there might only be a profit of $50-100/acre. Interestingly for land owners, typical solar farm 25 lease proposals are $800-1200/acre depending on their proximity to power lines and distribution. There is reduced fertilizer pollution runoff and soil erosion by having perennial plantings under the panels. There are also the added benefits to the region of employing installers, electricians, distribution, and long-term maintenance workers. Illinois' current renewable generation is 1,415 GWh, mostly wind power, which is about 7% of the total electricity generated.

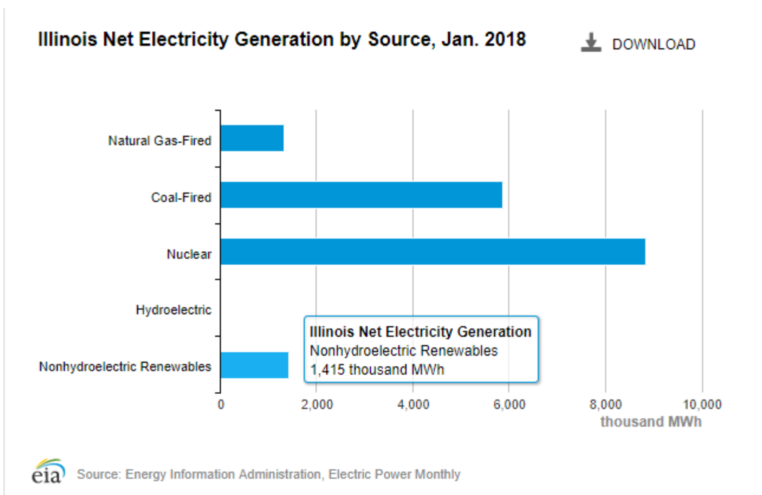


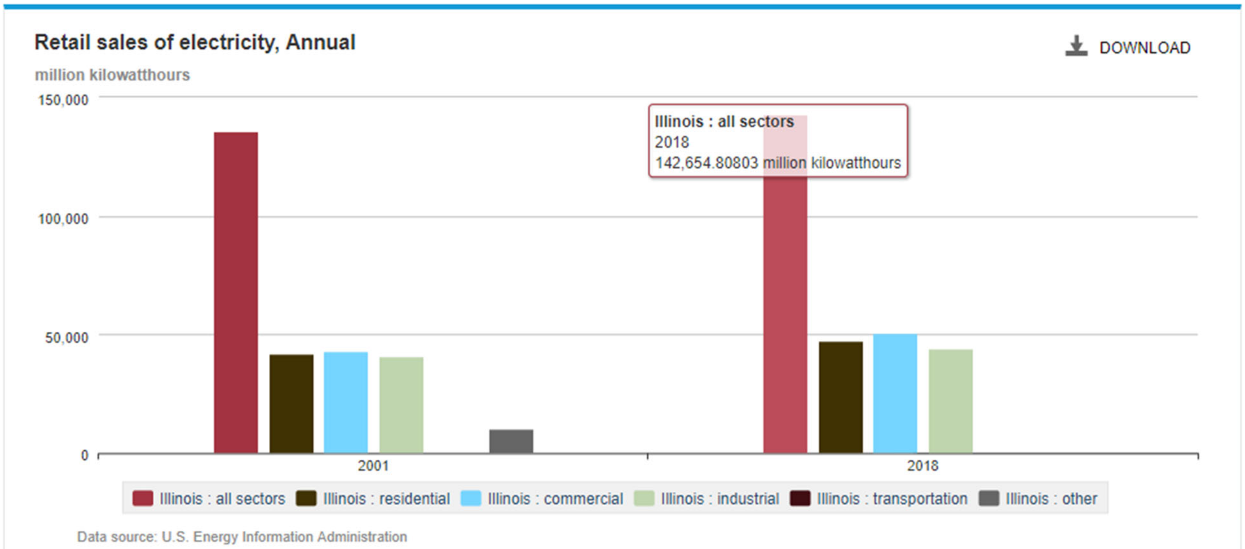
Figure 20: Illinois net electricity generation, from the EIA

In 1820, Illinois had 22 million acres of prairie and 14 million of forests. In 2018, Illinois had 27 million acres of farmland out of the 36 million acres total, or about 75% farmland. Illinois has an annual electricity use of 142,600,000 GWh.[13] This is a summer peak of 15,000,000 GWh/mo and a winter peak of 10,000,000 GWh/mo. Solar farm data shows production of about 370 MWh/acre over the course of a year can now be achieved. Roughly 385,000 acres of land, or 1% of the land in the state would be required to produce all of this electricity with solar. Agricultural data shows that Illinois is about 60% corn and soybeans. It is interesting to consider what the landscape would be like if it were 59% corn and soybean and 1% solar farms.

With reduced winter solar production, this would require about 3x more solar to be deployed, although this would mean that 60% of the summer production would have to be curtailed or used for other uses. Such daily and seasonal fluctuation presents interesting future challenges. Possibly new industries like daytime fertilizer or hydrogen production facilities will be a part of the future energy landscape. Existing

[11] https://www.illinois.gov/sites/ipa/Pages/Renewable_Resources.aspx
[12] https://www.acrevalue.com/map/IL/Champaign/?lat=40.14035&lng=-88.19621&zoom=10
[13] https://www.eia.gov/electricity/data/browser/

nuclear power plants are baseload/night power generation for the Illinois grid. Possibly these nuclear plants could run continually in the winter, but take downtime in the summer for planned maintenance. There are also some synergies with the seasonal fluctuations of wind in the Great Plains, where spring and fall are more windy, but wind power is naturally reduced in the summer when solar produces the most.



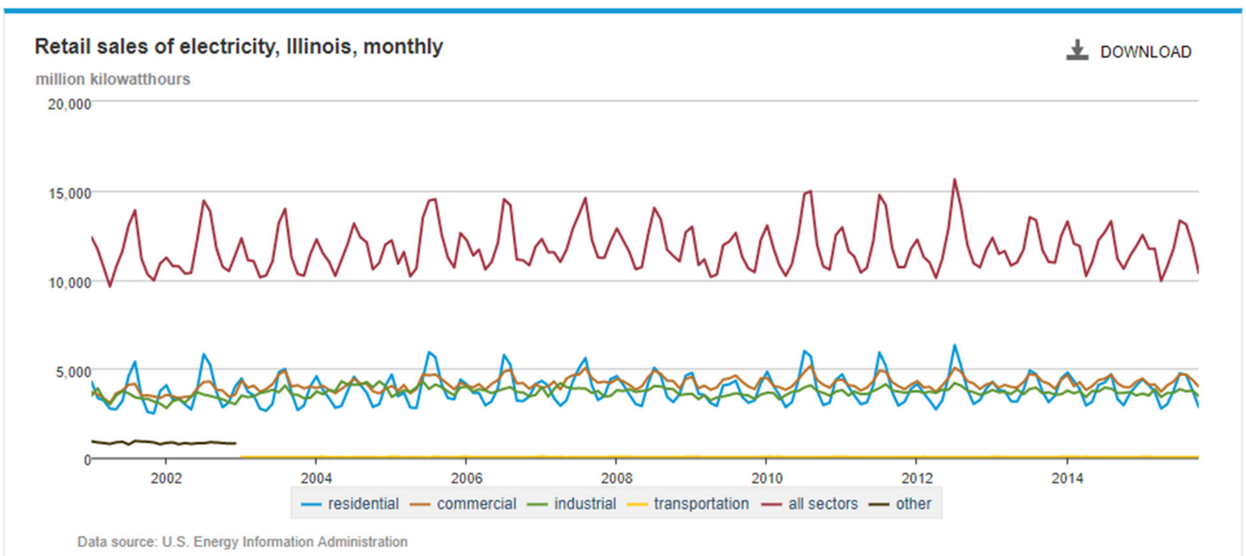


Figure 21: Annual and monthly electric consumption in Illinois

Champaign County Solar Resources

In the summer of 2018, the Champaign County Zoning Board of Appeals held public hearings to consider county zoning requirements for solar farms. I attended these meetings and presented details about my personal solar projects at home and church. It was informational and helpful for all parties to understand there are already examples in this area. Many neighboring counties are also looking into the same zoning questions. According to the Kankakee County Planning (Case 895-AT-18, ZBA 03/01/18, Page 1 of 18 Page 101), the FEJA incentives for 3,000 MW of new solar and 1,300 MW of new wind would require between 8,000 and 15,000 acres statewide. This would comprise 0.04% of the farmland in the state.   Even if all 8,000 acres were in Champaign County, which has over 600,000 acres of farmland, this would only be 1% of the farmland.   The largest solar farm being discussed in the county is a 150MW farm prosed southeast of Sydney. It would have 1,200 acres of panels and cover 1,600 acres of land--including setbacks and vegetative borders.

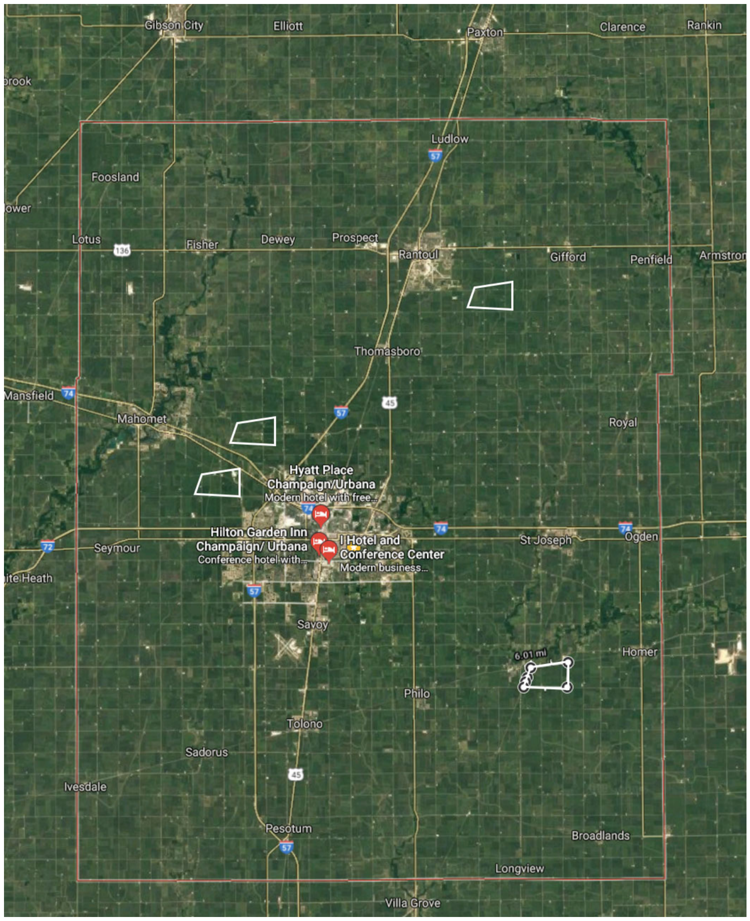


Figure 22- Illustration showing the Sidney Solar Farm and three others like it

Putting solar panels on rooftops and reducing load at the source is a good idea, but putting them on the ground is much less expensive, due to the economy of scale. Putting solar panels above parking lots on raised structures is possible but is much more expensive and resource intensive due to the added cost of all the steel structure. Google Project Sunroof (Figure 23) has some estimates of the potential for rooftop solar in the county based on LIDAR data. That estimate shows that there is potential for about 400 MW on flat roofs and 150 MW on south-facing roofs. Even getting 10% of these people to put solar on their roofs would be a major challenge and if each roof basically offsets its own energy use over a year, this will only be a small piece of the pie.

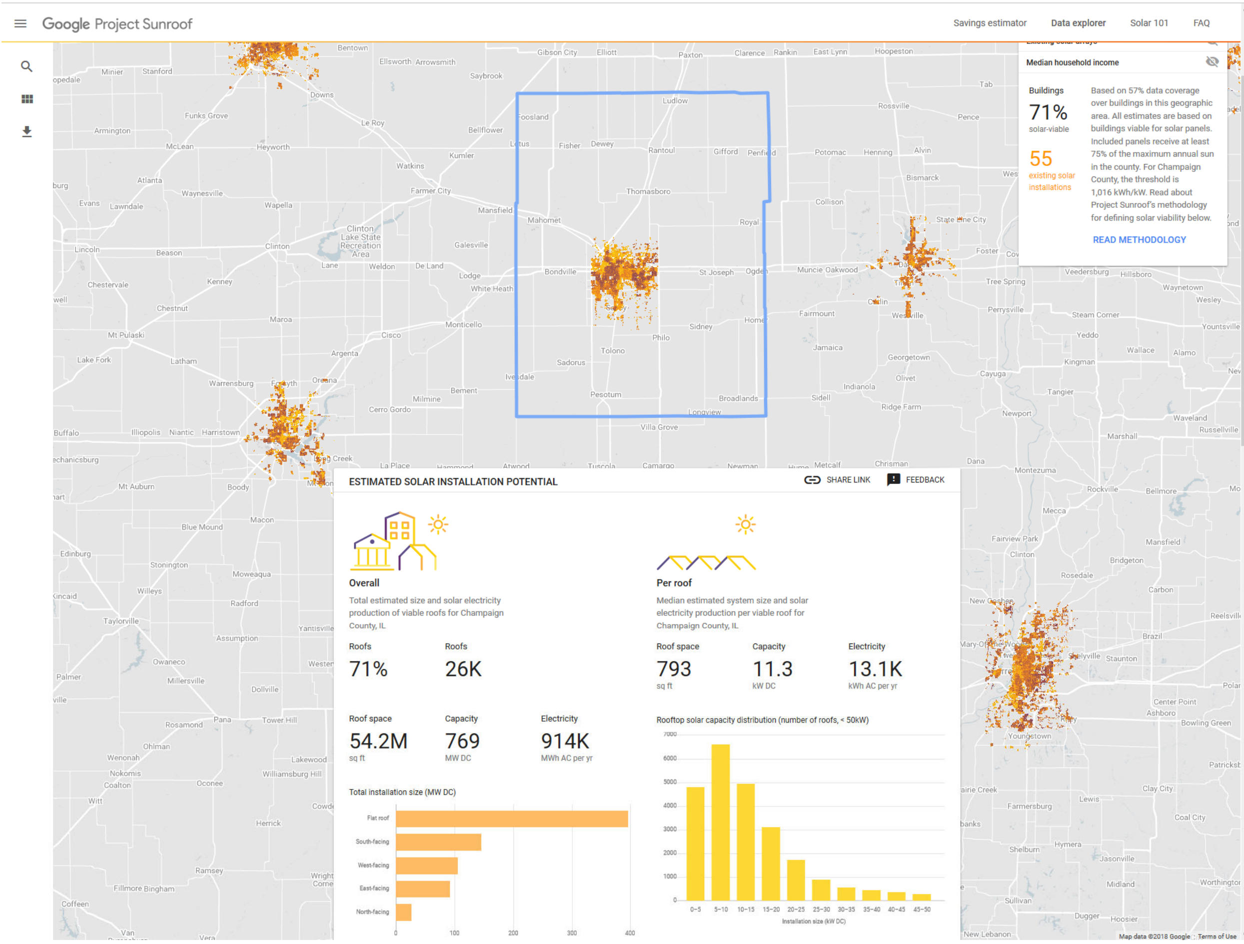


Figure 23- Google Project Sunroof showing county rooftop solar potential

In spring 2019, there were 8- to 10 times more applications for solar farm interconnection agreements than there were incentives available. It is likely that many proposed projects may become more competitive and may result in only the best projects getting subscribers and going forward. This may result in favoring projects with lower maintenance costs or dual uses such as agricultural co-uses with chickens, sheep, or bushes or pollinator-friendly plantings that support bees and honey.

The land is not being “wasted,” as it is just a different type of farming. With proper seed mix selection, the area under the solar panels can be planted with low-growing native plants that support pollinators like bees and butterflies, support wildlife like pheasants and birds, and sequester carbon in their roots (see Figure 21). Experiments could even be done with increasing the row spacing to allow for vegetable row-crops between the arrays. East-west fixed arrays like the UI solar farm 1.0 have to be spaced far enough to not be shaded in the winter, but with the summertime sun higher overhead, sunlight falls onto the ground between panels and can support plant growth.

Figure 24: Original illustration by Heidi Natura[14]

Planting low prairie plants under the panels can support pollinators, generate a local honey industry, decrease stormwater runoff, and sequester carbon in biomass and roots underground. Studies by NREL are looking into the potential for solar farms with cool plantings to be more efficient than solar farms over barren dirt or gravel. Soil can potentially store between 1.5 to 5.5 billion tons of carbon a year globally. That is equivalent to between 5 and 20 billion tons of carbon dioxide, compared to the 32 billion tons of CO_2 emitted from fossil fuels globally.

This could result in a dramatic increase in flowering areas for impacted species such as Monarch butterflies, which are already greatly affected by common practices such as monoculture crops, urban lawns, and mowing along roadways. Environmental advocacy groups such as Sierra Club, the Environmental Defense Council, and Pheasants Forever are participating in the discussion and shaping the guidelines around pollinator support. The effort to create a pollinator-friendly score card is being led by the Illinois Department of Natural Resources and a group out of the University of Illinois Pollinatarium[15] . The proposed legislation is called the Pollinator Friendly Solar Site Act (Illinois Pub. Act 100-1022)[16].

A study from the University of California, Davis, found that grasslands and rangelands are more resilient carbon sinks than are forests. The study suggests that carbon stored in the soil would be less affected by forest fires.[17]

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14 https://www.beeculture.com/can-solar-sites-help-save-bees/
15 https://pollinatarium.illinois.edu/resources/
16 https://www.dnr.illinois.gov/conservation/PollinatorScoreCard/Pages/default.aspx
17 https://phys.org/news/2018-07-grasslands-reliable-carbon-trees.html

Data from a 2015 MIT report show that 33,000 km2 (8.2 million acres, or 13,000 square miles) of solar PV could meet the entire electricity need of the United States in 2050.[18] That is similar to the area currently covered by roads nationwide, half of the land used to grow corn for ethanol, or only 1.3% of grasslands. An interesting study would be to look at how much land area there is adjacent to roads and interstate highways or under existing power line right-of-ways. Orienting solar arrays along east-west corridors could help this solar array follow the sun throughout the day. Spacing these arrays along north-south lines would further help to avoid areas of cloud cover. To ensure maximum daylight exposure, some factor more than this would be needed, but it is interesting to think about the relative areas needed.

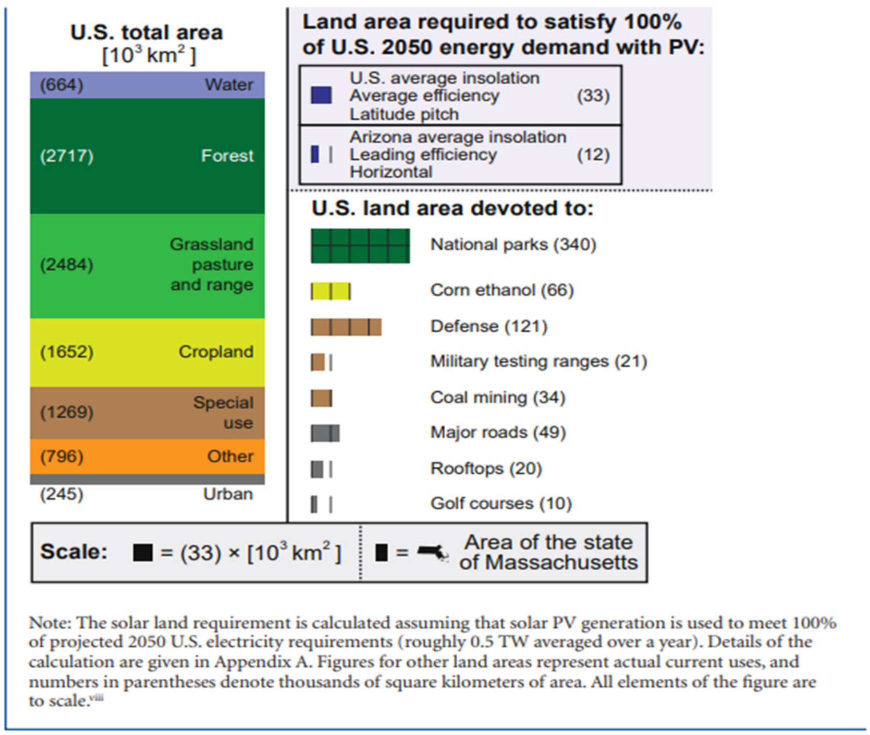

Figure 25: *Figure 33: MIT Land Use Solar Possibilities Study*

Solar farms are generally limited by easy access to power line transmission and local sub-stations. There are three large power sub-stations in rural Champaign County; Rising, Sydney, and Rantoul. If Champaign County had one large 1,000-1,400 acre farm and 8 to 10, smaller 10-acre farms, this 2,000 acres would be 0.3% of farmland in the county. This would provide 600 MW of clean energy to our local grid, which could power about 90,000 homes. The electricity produced by these solar farms would benefit thousands of people in our local grid and would benefit everyone with less load on existing power lines, a more robust grid, and reduced pollution from coal and natural gas-fired power plants.

[18] http://energy.mit.edu/wp-content/uploads/2015/05/MITEI-The-Future-of-Solar-Energy.pdf

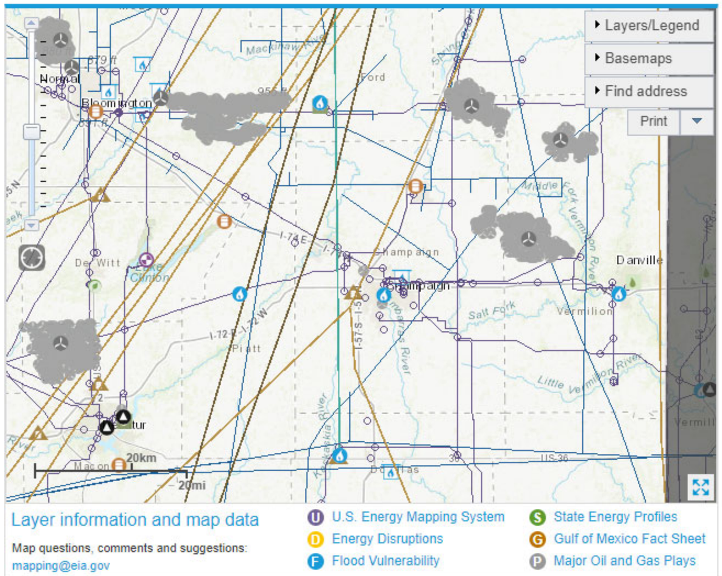

Figure 26: EIA map showing IL production and transmission

With the existing power lines in the county, and capacity in the larger metro markets of Chicago, Indianapolis, Springfield and Decatur, this region could be a net-exporter of electricity and have periods of time when it is 100% powered by renewable wind and solar energy. Future expansion of the use of batteries, thermal storage (hot/cold water), and hydrogen would be required to allow Champaign County to be 100% powered by renewable energy year-round. These energy storage projects are likely to be restrained in the near-future by the economics of low local fuel cost and high battery costs. However, with the costs of battery storage decreasing and costs on fossil fuel emissions increasing, energy storage projects will be more and more common.

Conclusion

The expansion of solar power on homes, businesses, churches, Universities, and farms presents opportunities to clean up our fossil fuel-dominated utility grid. Illinois is uniquely situated in the center of the country with strong electrical transmission grids, transportation roadways, a robust workforce, and the social and political will to make positive change.

With current trends in solar prices dropping, solar power is currently cost-competitive with local nuclear and coal power. State incentives such as the Illinois Future Energy Jobs Act reduced that initial cost hurdle further, as evidenced by so many proposed solar farms in the area. Solar-plus-storage is starting to become cost-competitive at a time when new nuclear plants are extremely costly to build and new coal plants are required to install expensive air quality equipment. Natural gas plants are currently benefitted by low fuel costs, but this trend is not guaranteed. In comparison, the cost of leased and built solar farms is locked in for the life of the system with no added fuel costs.

Farmland should be treated as a precious resource, but converting less than 1% of this land to provide renewable power for thousands of people and the potential ecological services such as pollinator-friendly plantings, far outweigh the impacts on farmland. The ground, air, and our community would be better off for setting more land aside for this type of energy production and ecological diversification.