Electric and Thermal Energy Strategies for Minnesota Swine Farms:

Finance and Economics

Presented by:
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Presented at:
Midwest Farm Energy Conference
June 14, 2017

Village of Hancock, Stevens County, MN
Circa Early 20th Century

Why renewable energy and energy efficiency for farms?

1. **The technology has improved** (less expensive, more reliable, produce more, easier / safer to interconnect and maintain).
2. **The systems can be practical and may provide a reasonable financial return.**
3. **State and Federal incentives are available to farmers.**
4. **Ag commodity processors and retailers may place a premium (or mandate) low carbon footprint products.**
5. **Renewable energy fits the farming philosophy** (Land-based, creates independence, may improve efficiency, production of a commodity).

University of Minnesota West Central Research and Outreach Center

WCROC 27 kW Solar PV System on Swine Finishing Facility

WCROC 50 kW Solar PV System (TenKSolar Ground Mount)

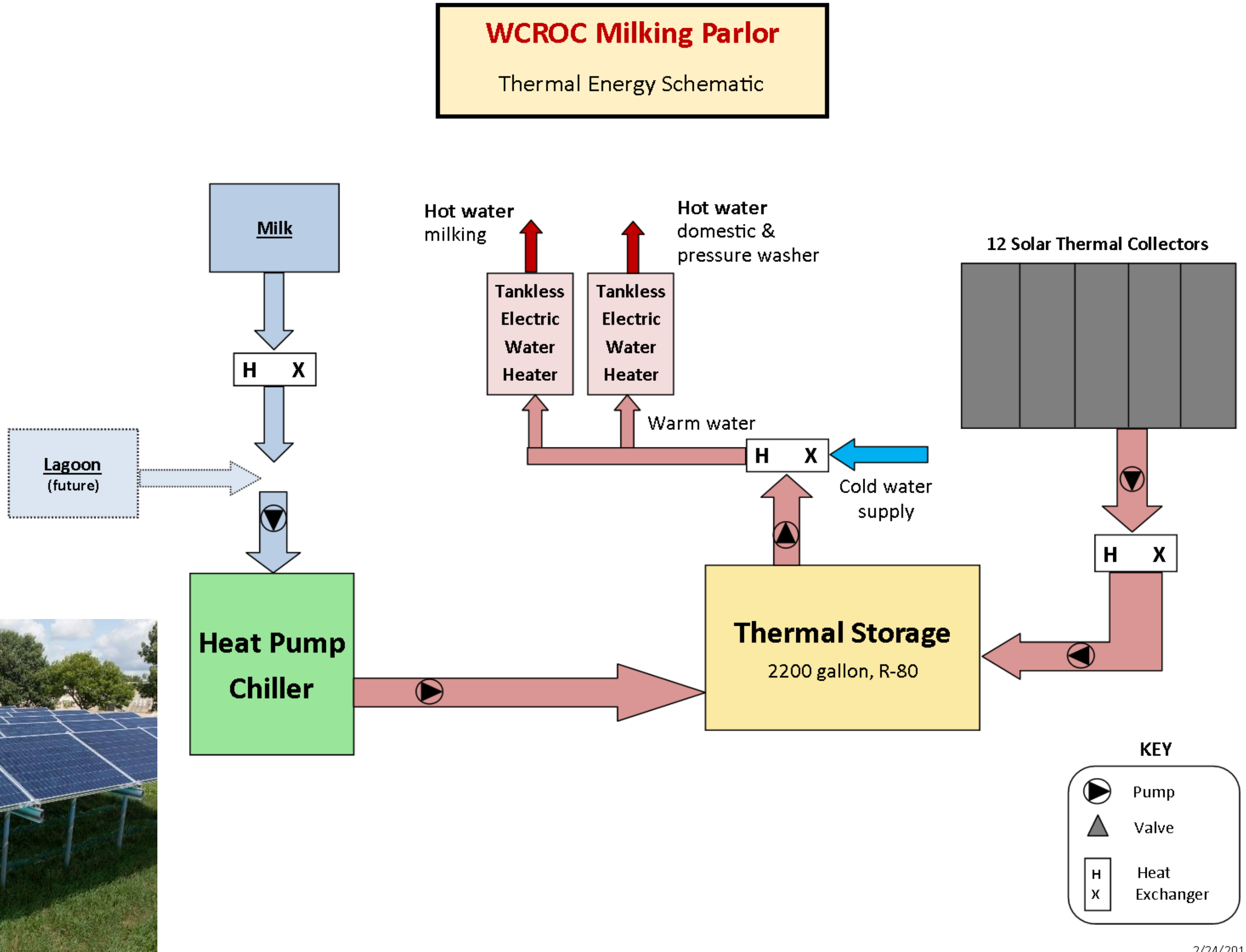
WCROC Solar Thermal Systems

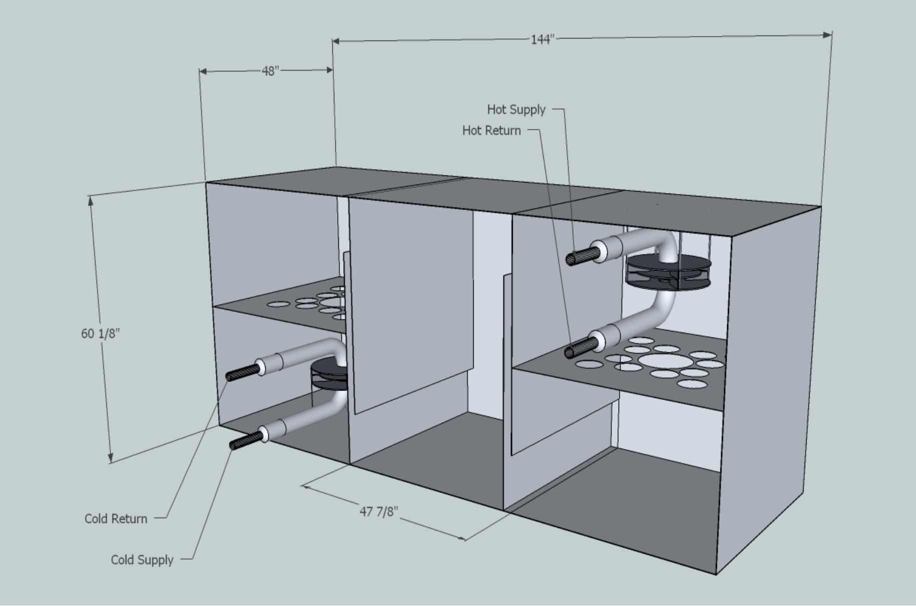
Evacuated Tube Collector

Absorption Chiller

Two 10 kW Wind Turbines

54 kW Solar PV




144"
48"
Hot Supply
Hot Return
60 1/8"
47 7/8"
Cold Return
Cold Supply


Flat Plate Collector

WCROC 10 kW Ventera Wind Turbines

Installation in Winter 2017

<u>SPECIFICATIONS:</u>

Wind Turbine—Model VT10—240
10kW at 29mph-13m/s
Cut—In Wind Speed: 6mph-2.7m/s,
Survival Wind Speed: 130 mph-58 m/s
Total Weight of turbine and blades:
580lbs – 263kg
3 blade, downwind,
Diameter: 22 feet-6.7m
Swept Area: 380 SF/35.25 SM
RPM: 270 peak,
Blade: Glass fiber engineered plastic,
injection molded
Generator Rating: 15kva 240vac
at 250rpm, 3 phase

WCROC 10 kW Ventera Wind Turbines

Installation in Winter / Spring 2017

SPECIFICATIONS:

Assembled Foundation

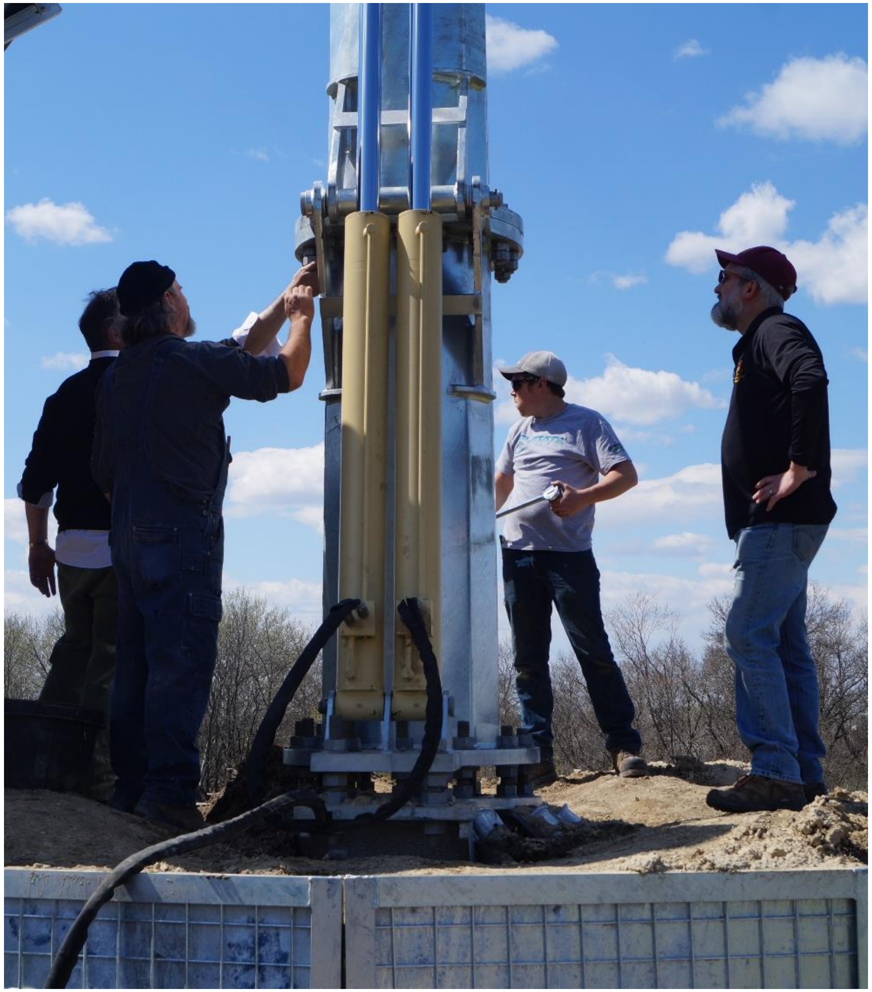
- 50,000 lbs of ballast for 70 foot tower
- More ballast required for larger pole
- Site Prep
    - Removed 4 feet of soil
    - Added 4 feet of packed Class 5 gravel
    - 25 foot diameter prepped
    - 15 foot diameter foundation
    - Foundation is 7 feet tall

WCROC 10 kW Ventera Wind Turbines

Assembled Foundation

WCROC 10 kW Ventera Wind Turbines

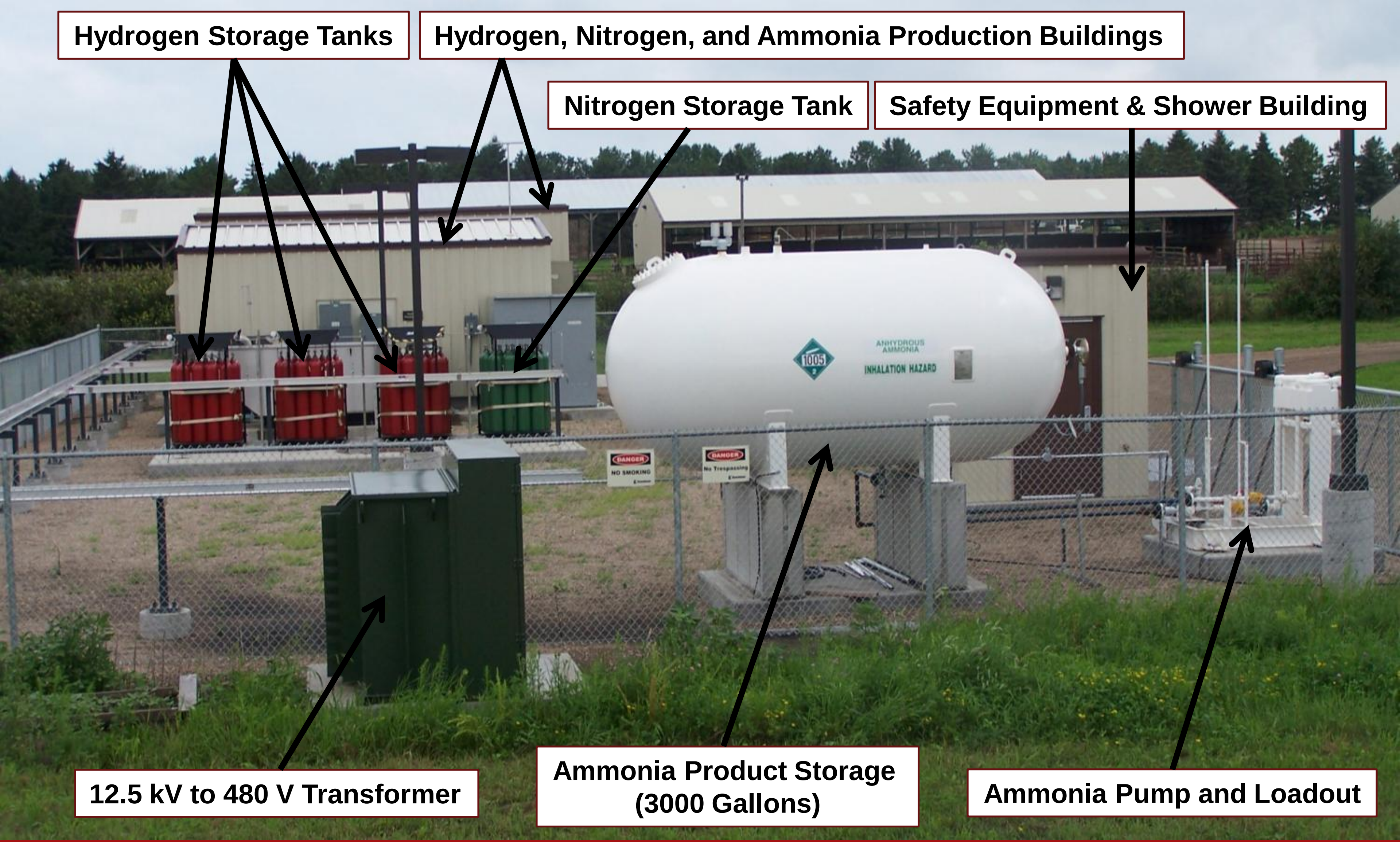
Installation in Spring 2017



Renewable Fertilizer: An Elegant Idea

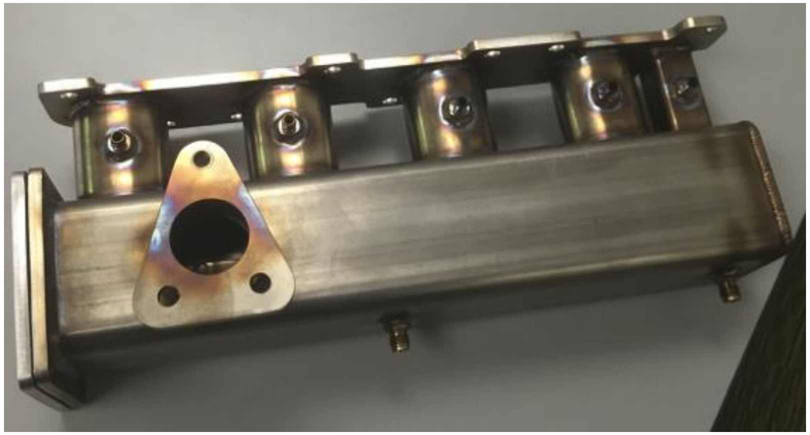
Wind Energy + Water + Air = Nitrogen Fertilizer

Renewable Hydrogen and Ammonia Pilot Plant



Ammonia Fuel Research

John Deere Diesel on Dynamometer



Integrated Reactor Manifold

Displacing 50% of Diesel Fuel in Tractors

In general, the best current opportunities for swine producers:

1. Energy Efficiency Improvements

2. Solar Photovoltaic (Solar Electric)

-Other opportunities possible on case-by-case basis.

Potential for Energy Efficiency Improvements at WCROC Swine Facilities

			Electricity + Propane	
Energy Conservation Measure	Barn Applied to	Investment Costs	Payback Period (years)	Annual Return on Investment
Night Temperature Setback	N	$ 500.00	**0.2**	**458.8%**
Variable Speed Fans	N	$ 1,000.00	**3.4**	**25.7%**
Earth Tube	Fa	$ 10,000.00	**3.9**	**21.8%**
Heat Lamp Controllers	Fa	$ 3,000.00	**6.1**	**17.1%**
LED Lighting	N	$ 12,000.00	**17.0**	**1.9%**
Geothermal Heat Exchange	Fa	$ 175,000.00	**27.7**	**-0.4%**
Traditional Air Conditioning	Fi	$ 80,000.00	**-**	**-4.01%**
Solar Chimney	N	$ 6,000.00	**-**	**-7.1%**

AKF Group LLC, 2016 (Study commissioned by WCROC)

Why Solar PV?

1. Capital costs have decreased significantly in last decade

2. Low Operation, maintenance, and repair – Increased longevity and durability

3. Technology has improved

4. Generation best matches load or highest generation during peak loads

5. Grants and incentives available to farmers and other businesses

6. Large southern facing roofs on swine barns MAY BE a benefit

***Solar PV will NOT be a good fit for all swine farms!**

Grants and Incentives: (Partial List)

1. **Property Assessed Clean Energy (PACE)**
   -5 to 10 year loan paid back through real estate tax
2. **USDA Rural Energy for America Program**
   -Grant for up to 25% of capital cost - Loan program available
   -Competitive application process – low success rates
3. **MN AGRI Livestock Facility Loan Program**
   -Grant for up to 5% of an energy system tied to livestock facilities - $50k max ($25k /year)
   -About 60% of qualified applicants are funded

Grants and Incentives: (Partial List)

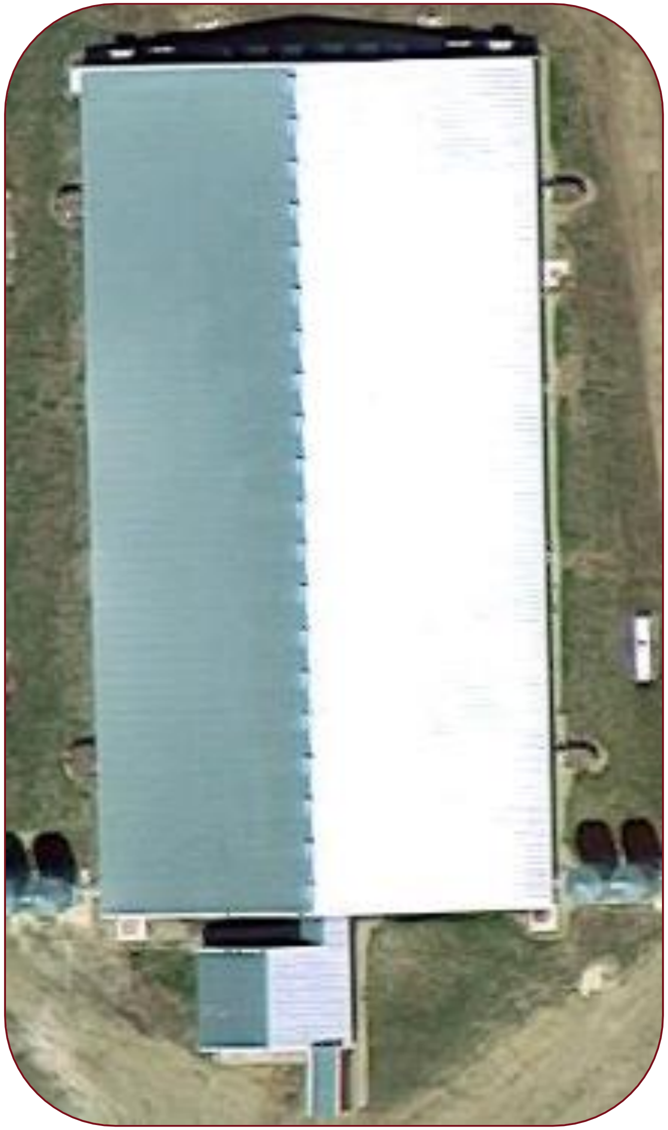
4. **Utility Incentives:**
   Made-in-Minnesota Solar Program – Provides payments between $0.10-$0.13 / kWh for 10 years for commercial systems below 40 kW nameplate in an IOU service territory
   Xcel Solar Rewards – Payments for $0.08 . kWh for 10 years for residential or business systems less than 20 kW.
   Net Metering – For systems less than 40 kW in nameplate capacity.
   -Check with your utility for other potential incentives such as **CIP payments**.

5. **Federal Investment Tax Credit (ITC)**
   -30% ITC through December 31, 2019 – then rate decreases
   -Capital costs x .3

6. **Modified Accelerated Cost Recovery (MACRS) Depreciation**
   -MACRS Depreciation for Years 0-5
   -85% of solar PV capital costs (due to ITC benefit)
   -Depends on federal tax rate for individual (Eg. 28% or 38%)

Case Study: 2400 Head Swine Finishing Unit

Owner is participating in energy audit study and requested solar PV analysis

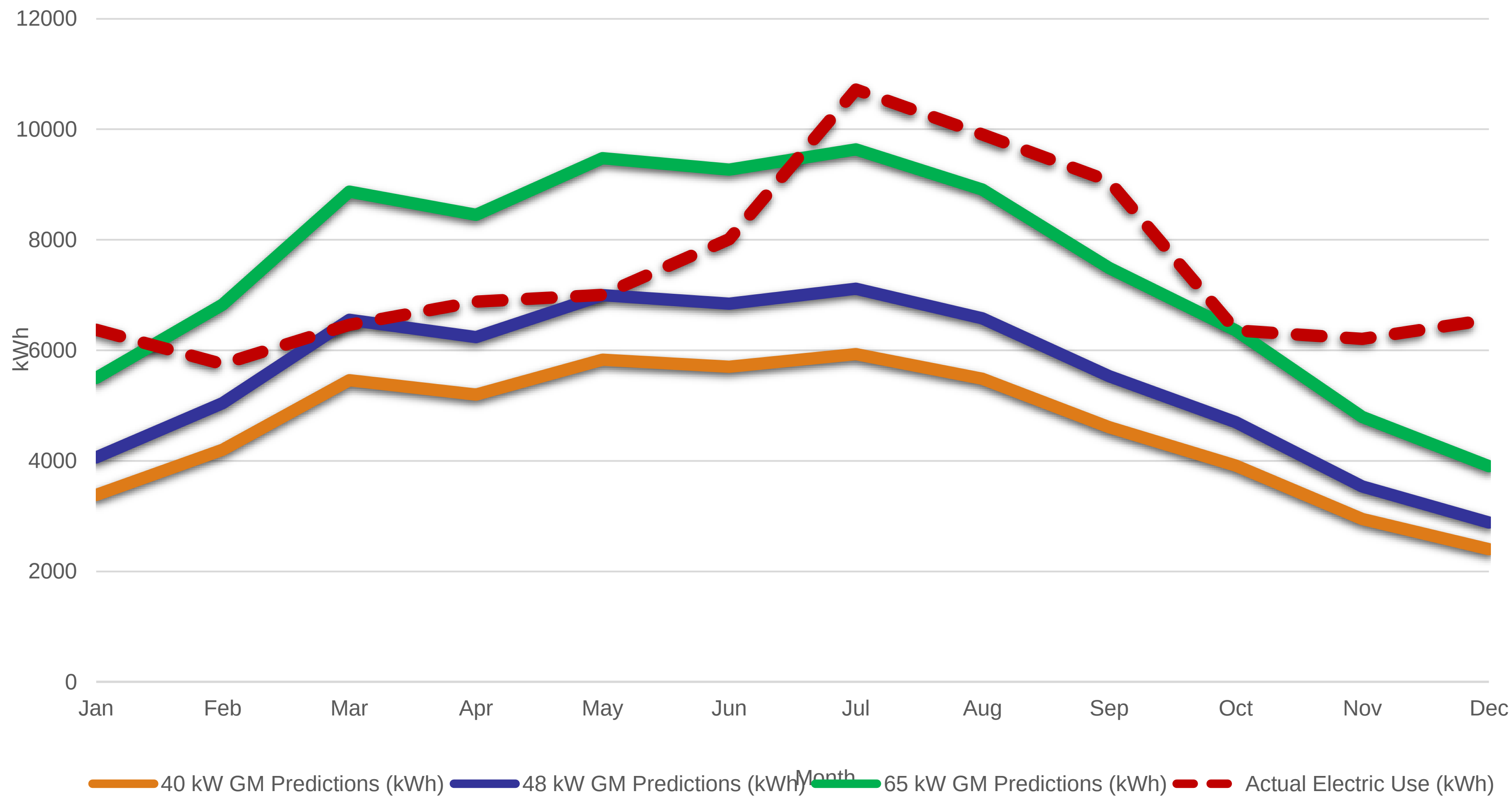


Specifications:

- 2400 head divided into two 1200 head rooms
- 100 feet x 200 feet (20,000 square feet)
- Building is oriented north and south
- Tunnel ventilated
- 5,800 hogs per year
- 89,287 kWh total electrical energy use per year
- 7,441 kWh average electrical energy use per month
- 10,720 kWh per month maximum (July)
- 5,749 kWh per month minimum (Feb)

Case Study: 2400 Head Swine Finishing Unit

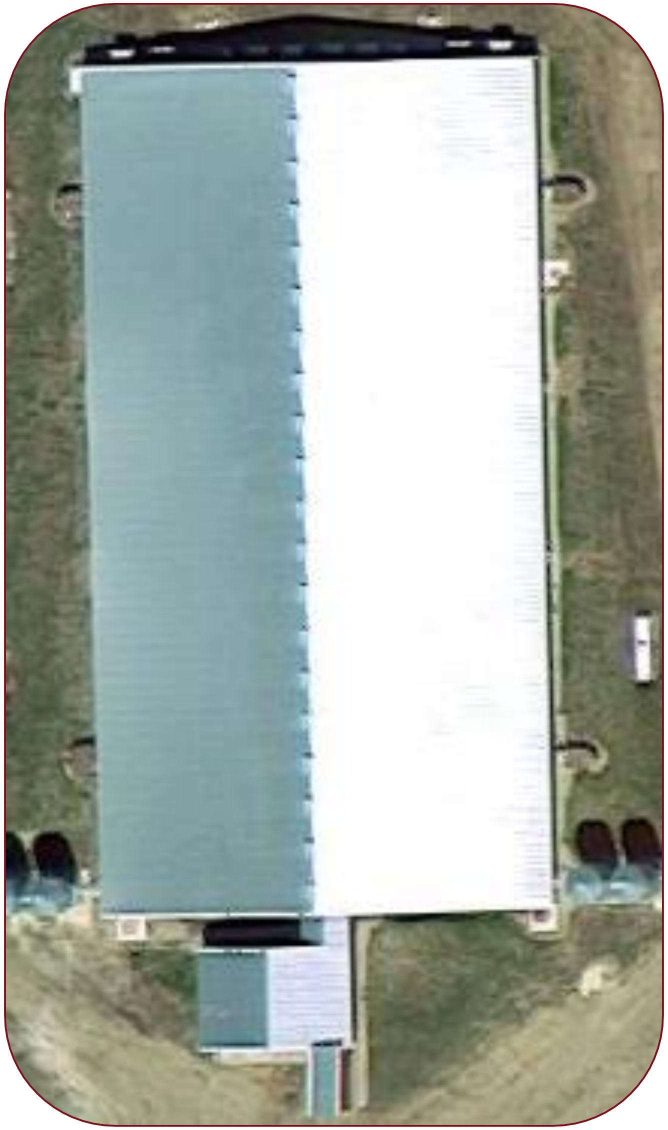
System Sizing - Load vs Projected Generation



Case Study: Financial Pro Forma for Solar PV

Assumptions:

- Capital cost equals $3 /watt of nameplate
- Production estimated by multiplying nameplate capacity (in watts) by 1.4
- $0.10 / kWh in Year 1 (3% escalator)
- 25-year life expectancy of solar system
- 25-year warranty on panels and brackets
- 20-year extended warranty on inverter(s)
- 1-year warranty on install
- 28% federal tax bracket
- 4% Interest – debt or owner equity
- 10-year debt
- <u>Assumed could make full use of tax benefits</u>
- Module degradation rate of 0.5% per year
- 3% inflation rate per year on electric rate and operating expenses



Case Study: Financial Pro Forma for Solar PV

Three sizes evaluated:

<u>20 kW nameplate with:</u>

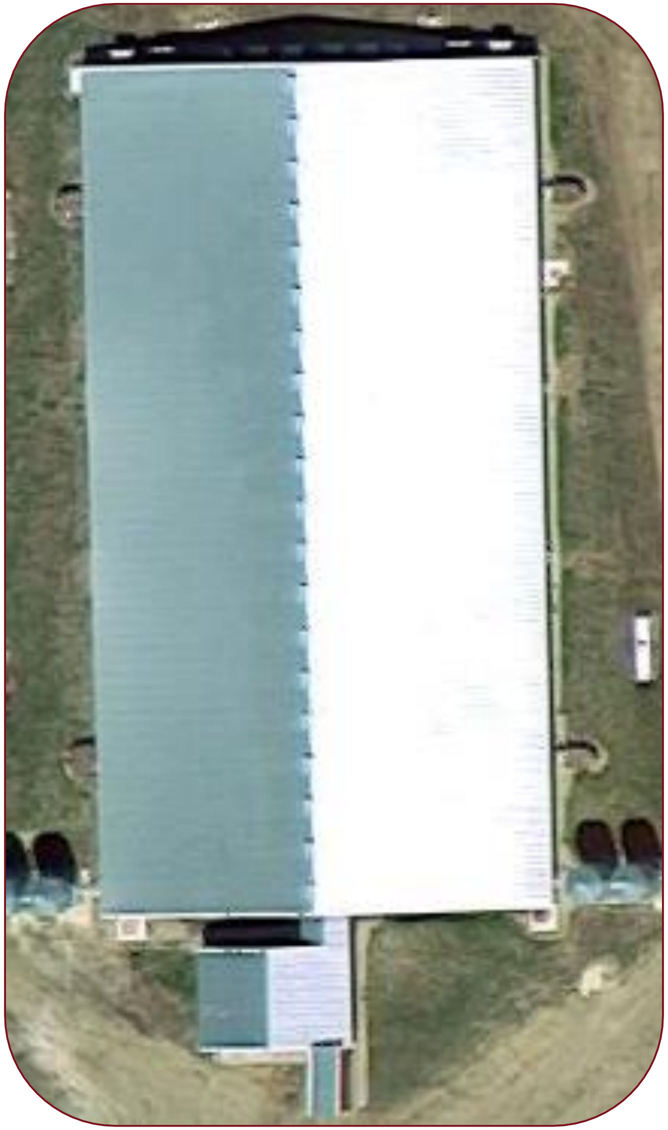
1. Tax Benefits Only
2. USDA REAP and MN AGRI Livestock Grant
3. Xcel Solar Rewards ($0.08/kWh for 10 years)
4. Xcel Made-in-Minnesota
5. All Benefits (5a – Solar Rewards, 5b – MiM)

<u>40 kW nameplate with:</u>

1. Tax Benefits Only
2. USDA REAP and MN AGRI Livestock Grant
3. Made-in-Minnesota Solar Incentive ($0.11/kWh for 10 years)
4. All Above Benefits

<u>65 kW nameplate with:</u>

1. Tax Benefits Only
2. USDA REAP and MN AGRI Livestock Grant



Case Study: Financial Pro Forma for Solar PV

YEAR	0	1	2	3	4	5	6
REVENUES							
Net kWh/yr		55073	54798	54524	54251	53980	53710
PPA Rate ($/kWh)		0.1000	0.1030	0.1061	0.1093	0.1126	0.1159
Utility Incentive (Xcel MiM)		0.1100	0.1100	0.1100	0.1100	0.1100	0.1100
Total Savings from Electric Bill		$11,565	$11,672	$11,782	$11,896	$12,013	$12,135
EXPENSES							
Operation & Mgt.		$250	$256	$263	$269	$276	$283
Financial Management		$250	$256	$263	$269	$276	$283
Service, Warranty, & Repair		$800	$800	$800	$800	$800	$800
Electrical Usage		$0	$0	$0	$0	$0	$0
Professional Services		$250	$258	$265	$273	$281	$290
Real Estate Tax Increase		$0	$0	$0	$0	$0	$0
Land Lease		$0	$0	$0	$0	$0	$0
Insurance		$360	$371	$382	$393	$405	$417
Demand and Other Utilty Charges		$116	$117	$118	$119	$120	$121
Total Expenses		$2,026	$2,058	$2,090	$2,124	$2,159	$2,194
Operating Cash		$9,540	$9,614	$9,692	$9,772	$9,855	$9,940
Debt Principle		$84,000	$77,004	$69,727	$62,160	$54,290	$46,105
Debt Service		$10,356	$10,356	$10,356	$10,356	$10,356	$10,356
Cash Flow (Op. Cash minus Debt Serv.)		-$817	-$742	-$665	-$585	-$502	-$416
GROSS INCOME							
Revenue		$11,565	$11,672	$11,782	$11,896	$12,013	$12,135
Minus Operating Expenses		$2,026	$2,058	$2,090	$2,124	$2,159	$2,194
Minus Interest (4 %)		$3,360	$3,080	$2,789	$2,486	$2,172	$1,844
Plus Depreciation @ 28% Tax Rate		$6,720	$10,752	$6,451	$3,871	$3,871	$1,935
Plus Investment Tax Credit		$36,000					
Net Taxable Income (Loss)		$48,900	$17,286	$13,354	$11,156	$11,554	$10,031
Cummalative Cash Flow with Tax Benefits	($84,000)	($35,100)	($17,814)	($4,460)	$6,696	$18,250	$28,281
ASSUMPTIONS		**40 KW**					
Project Cost		$120,000					
Debt		$84,000					
Equity							
REAP Grant		$30,000					
MN AGRI Livestock Grant		$6,000					
ACRS Depreciation-5 years @ 28 % Tax Bracket							

Case Study: Financial Pro Forma for Solar PV

Size (Name-plate KW)	Capital Costs ($)	1st Year Production (KWh)	1st Year Revenue ($)	ITC	MACRS Depre-ciation	Grants	Xcel Solar Rewards	MiM	Simple Payback (Years)
20 kW	$60,000	28,000	$2,800	●	●				18
20 kW	$42,000	28,000	$2,800	●	●	●			9
20 kW	$60,000	28,000	$5,040	●	●		●		10
20 kW	$60,000	28,000	$5,880	●	●			●	**8**
20 kW	$60,000	28,000	$5,040	●	●	●	●		**4**
20 kW	$60,000	28,000	$5,880	●	●	●		●	**3.5**
40 kW	$120,000	55,073	$5,507	●	●				18
40 kW	$84,000	55,073	$5,507	●	●	●			**9**
40 kW	$120,000	55,073	$11,565	●	●			●	**8**
40 kW	$84,000	55,073	$11,565	●	●	●		●	**4**
65 kW	$195,000	85,028	$8,503	●	●				18
65 kW	$136,500	85,028	$8,503	●	●	●			**9**

Other Considerations:

1. Capital Costs (Is it turn key? Permits, etc.)
2. Warranties
3. Work with a reputable contractor
4. Utility service territory – Demand Charges!
5. Can you fully utilize tax benefits?
6. Lower GHGs / Public Perception and Markets
7. Roof versus Ground Mount

   -Space available / suitability for solar panels

   -Snow – Cover panels, shift load / roof collapse

   -Age of roof /building

   -Obstacle for vehicles, snow blowing, etc

   -Cleaning

   -Multi-benefit - Shade / shelter

WCROC Finishing Barn 27 kW Solar Quotes (March, 2015)*

VENDOR	A	B	C	D
Panel	Heliene 280W	Solarworld 280W	Solarworld 280W	Solarworld 315W
Made in MN?	Y	N	N	N
Inverter	SMA Sunnyboy	Solaredge	Enphase	Solaredge
Monitor each panel?	N	Y	Y	Y
System size (kW)	25.2	27.44	24.64	30.24
System price	$ 91,267.00	$ 89,631.00	$ 118,575.00	$ 101,968.00
Permit/engineering	$ 2,080.00	$ 1,450.00	$ 5,000.00	$ 4,470.00
$/W	$ 3.54	$ 3.21	$ 4.61	$ 3.22

VENDOR	A	B	C	D
Panel	Silicon Energy 275W	Silicon Energy 275W		Silicon Energy 275W
Made in MN?	Y	Y		Y
Inverter	Enphase M250	Solaredge		Solaredge
Monitor each panel	Y	Y		Y
System size (kW)	24.75	26.95		18.15
System price	$ 123,487.00	$ 120,383.00		$ 104,441.00
Permit/engineering	$ 2,080.00	$ 1,450.00		$ 4,470.00
$/W	$ 4.91	$ 4.41		$ 5.51

WCROC Finishing Barn 27 kW Solar Bids (March, 2015)

VENDOR	A	B		
Panel	Heliene 280W	Heliene 280W		
Made in MN?	Y	Y		
Inverter	Solaredge	Solaredge		
System size (kW)	26.88	26.88		
System price	$ 99,004.50	$ 72,560.00		
Install with Prevailing Wages	$ 12,127.50	$ 13,578.00		
TOTAL SYSTEM COST	$ 111,132.00	$ 86,138.00		
$/W	$ 4.13	$ 3.21		

VENDOR	A	B		
Panel	SiE Voyageur 275 W			
Made in MN?	Y			
Inverter	Solaredge			
System size (kW)	26.95			
System price	$ 113,190.00			
Permit/engineering	$ 12,127.50			
TOTAL SYSTEM COST	$ 125,317.50		Difference:	$ 39,179.50
$/W	$ 4.65			

WCROC Dairy 50 kW Solar Bids (November, 2015)

VENDOR	A	B	C	
Panel	Ten K Solar	Ten K Solar	Ten K Solar	
Made in MN?	Y	Y	Y	
Inverter	Ten K	Ten K	Ten K	
System size (kW)	50.00	50.00	50.00	
TOTAL SYSTEM COST	$ 150,585.00	$ 196,378.00	$ 300,000.00	
$/W	$ 3.01	$ 3.93	$ 6.00	

			Difference:	$ 149,415

WCROC Finishing Barn 20 kW Solar Bids (November, 2016)

VENDOR	A	B	C	
Panel	Heliene 320W	Heliene 320W	Heliene 320W	
Made in MN?	Y	Y	Y	
Inverter	SolarEdge	SolarEdge	SolarEdge	
System size (kW)	19.84	19.84	19.84	
TOTAL SYSTEM COST	$ 59,235.00	$ 64,700.00	$ 76,400.00	
$/W	$ 2.99	$ 3.26	$ 3.85	

			Difference:	$ 17,165.00

WCROC Dairy 20 kW Wind Turbines (February, 2017)

Model	Ventera			
Made in MN?	Y			
System size (kW)	10 kW each – Two			
TOTAL SYSTEM COST	$ 148,000.00			
$/W	$ $7.40			


WARNING: PHOTOVOLTAIC POWER SOURCE
PHOTOVOLTAIC
DC DISCONNECT

MN Statute 216B.164 COGENERATION AND SMALL POWER PRODUCTION.

Subd. 2a.Definitions.

(l) "Standby charge" means a charge imposed by an electric utility upon a distributed generation facility for the recovery of costs for the provision of standby services, as provided for in a utility's tariffs approved by the commission, necessary to make electricity service available to the distributed generation facility.

(j) Net metered facility" means an electric generation facility constructed for the purpose of offsetting energy use through the use of renewable energy or high-efficiency distributed generation sources.

MN Statute 216B.164 COGENERATION AND SMALL POWER PRODUCTION.

Subd. 3.Purchases; small facilities.

(a) This paragraph applies to cooperative electric associations and municipal utilities. For a qualifying facility having less than 40-kilowatt capacity, the customer shall be billed for the net energy supplied by the utility according to the applicable rate schedule for sales to that class of customer. *A cooperative electric association or municipal utility may charge an additional fee to recover the fixed costs not already paid for by the customer through the customer's existing billing arrangement. Any additional charge by the utility must be reasonable and appropriate for that class of customer based on the most recent cost of service study.* The cost of service study must be made available for review by a customer of the utility upon request. In the case of net input into the utility system by a qualifying facility having less than 40-kilowatt capacity, compensation to the customer shall be at a per kilowatt-hour rate determined under paragraph (c), (d), or (f).

DSC: Distribution Standby Capacity

Total Distribution System Infrastructure Cost / Total Max System Demand = Distribution Reservation Fee Per KW

Per the cost of service study cost to build (1) kW of capacity into the distribution system is $4.29/kW
Distribution Reservation Fee Per kW updated on an annual basis

Setting the DSC and Monthly Billing

- On an annual basis the Coop sets the Distribution Standby Capacity for the DG system based on the average of the monthly max hourly demands of the account of the previous year.
- On a monthly basis the Member pays the Distribution Reservation Fee for the difference between the DSC and the actual recorded monthly hourly peak demand.

(DCS – Max Hourly Demand) * $4.29 = Monthly Distribution Reservation Fee

Runestone Electric Association, 2017

DSC: Distribution Standby Capacity

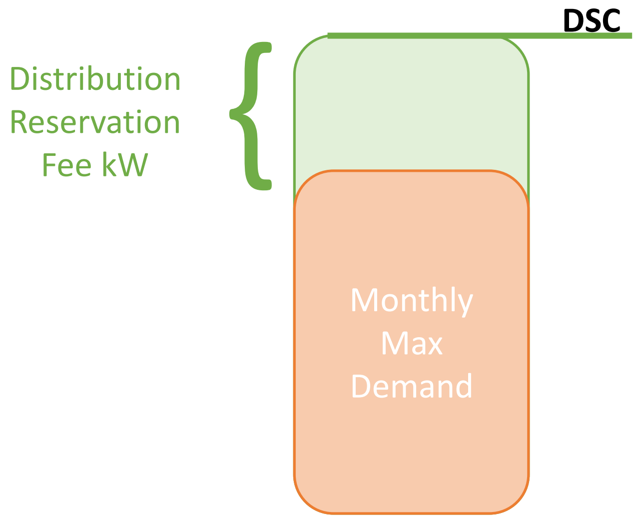
(DSC – Max Hourly Demand) * $4.29 = Monthly Distribution Reservation Fee

<u>Example</u>

ABC Commercial, LLC – installs a 65 kW solar system
2015 Average Monthly Max Hourly Demands: 160 kW

DSC set to 160 kW

	Net Demand	(DSC - Net Demand)	Distribution Reservation Fee
Jan	155	5	$21.45
Feb	150	10	$42.90
Mar	145	15	$64.35
Apr	140	20	$85.80
May	142	18	$77.22
Jun	150	10	$42.90
Jul	160	0	$0.00
Aug	155	5	$21.45
Sep	145	15	$64.35
Oct	140	20	$85.80
Nov	150	10	$42.90
Dec	175	0	$0.00



GRE Standby and Supplemental Service

- The Contracted Standby Demand (CSD) is a value that is based on the AC output capacity of the Member's Generation in kW. For this example we are assuming a generator has been installed with an AC output capacity of 133 kW.

- Billing units for the GRE Standby Reservation Fee will be established during the GRE monthly coincident peak hour.

- The amount of *Standby Usage* kW is included in REA's wholesale power bill as part of the normal wholesale metering and billing process.
    - Assuming total load at the member site exceeds 133 kW, then the Standby Usage kW equals the CSD minus the capacity provided by the solar system during the GRE monthly coincident peak hour.
    - If total load is less than 133 kW, then the Standby Usage kW will be the total load minus the capacity provided by the solar system during the GRE monthly coincident peak hour.

- The Standby Reservation Fee kW will be the CSD minus the Standby usage kW

- Following are example calculations:

133	Contracted Standby Demand (CSD)					
Total Load	180	180	180	120	120	120
Generation Capacity Provided by Solar	133	100	0	0	50	133
Standby Usage kW	0	33	133	120	70	0
Supplemental Usage kW	47	47	47	0	0	0
	180	180	180	120	120	120
Excess to Utility Grid						13
Standby Reservation Fee (kW)	133	100	0	13	63	133
Billed Usage Demand (kW)	47	80	180	120	70	0

Great River Energy, 2017

Reservation Fees

GRE shall charge the member a monthly reservation fee equal to the fee specified in the table below multiplied by the member-consumer's CSD specified in the ESA for either firm or non-firm standby service.

2017 Monthly Reservation Fees (per kW of Contracted Standby Demand)			
Billing Month	GRE Season	Firm Standby Service*	Non-Firm Standby Service
January	Winter	**$2.24**	$0.00
February	Winter	**$2.24**	$0.00
March	Spring	**$1.53**	$0.00
April	Spring	**$1.53**	$0.00
May	Spring	**$1.53**	$0.00
June	Summer	**$2.94**	$0.00
July	Summer	**$2.94**	$0.00
August	Summer	**$2.94**	$0.00
September	Fall	**$1.53**	$0.00
October	Fall	**$1.53**	$0.00
November	Fall	**$1.53**	$0.00
December	Winter	**$2.24**	$0.00

*Each monthly rate includes $0.83/kW for standby transmission & ancillary services.

Great River Energy, 2017

Avoided Cost Rates Paid by GRE

2017 avoided cost rates	Energy (&/kWh)	Capacity[3] ($/kWh)	RECs[4] ($/kWh)
Summer months (May, June, July, August, September, October)			
On-peak[1]	$0.03520	$0.00	$0.001
Off-peak[2]	$0.02001		$0.001
Or, if eligible[3]			
All hours[3]	$0.02681	$0.00	$0.001
Winter months (January, February, March, April, November, December			
On-peak[1]	$0.03573	$0.00	$0.001
Off-peak[2]	$0.02435		$0.001
Or, if eligible[3]			
All hours[3]	$0.02936	$0.00	$0.001
Annual (January through December)			
All hours[3]	$0.02808	$0.00	$0.001

Footnotes: 1 On-Peak hours are defined as weekdays from 10:00 to 20:00 CPT except for the following holidays: New Year's Day, Memorial Day, Independence Day, Labor Day, Thanksgiving Day and Christmas Day. 2 Off-Peak hours are defined as all hours besides on-peak hours. 3 All hours rates are only available for QFs that provide Firm Power as defined in Minnesota Rules 7835.0100. 4 Only available for energy produced by a QF using an approved renewable technology and for which Great River Energy receives all Renewable Energy Credits (REC), tradeable emission credits, green tags and other associated renewable and environmental attributes.

Great River Energy, 2017

So what do standby service charges mean to farmers and others on REA systems wishing to install renewable energy generation?

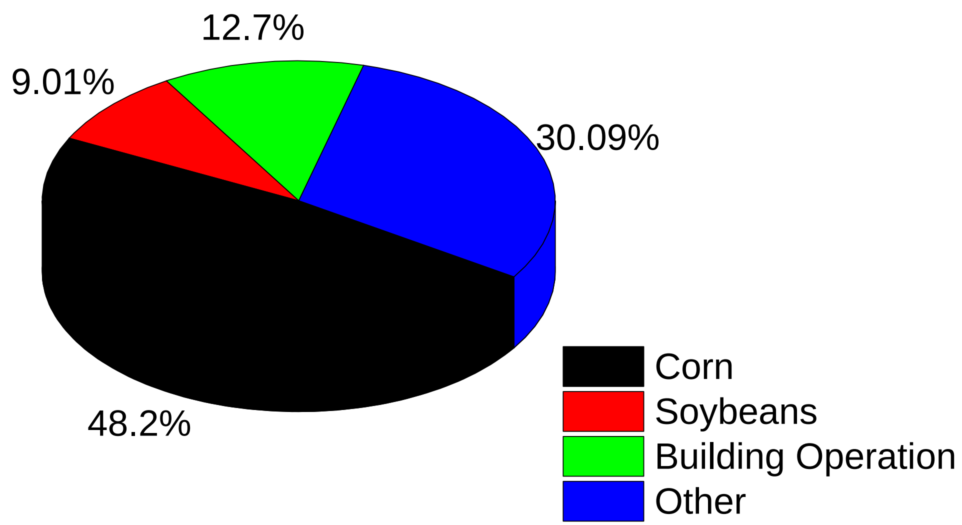
- Farmers face market and regulatory pressures to reduce the carbon footprint of commodities
- Financial feasibility of renewable generation is much more challenging to determine considering standby charges
- Complexity is a disincentive
- Multi-generation farms, businesses, homeowners have paid for infrastructure – charges should account only for added expense
- Perhaps need more balanced approach with set charges
- In addition to full accounting of expenses of interconnect, fully account for value of generation

Energy Use in the Swine Production System

Major Energy Areas

(CED Method, SimaPro 8.2)

- Requires roughly 9.4 MJ/kg
- Corn production accounts for almost half of the energy used.



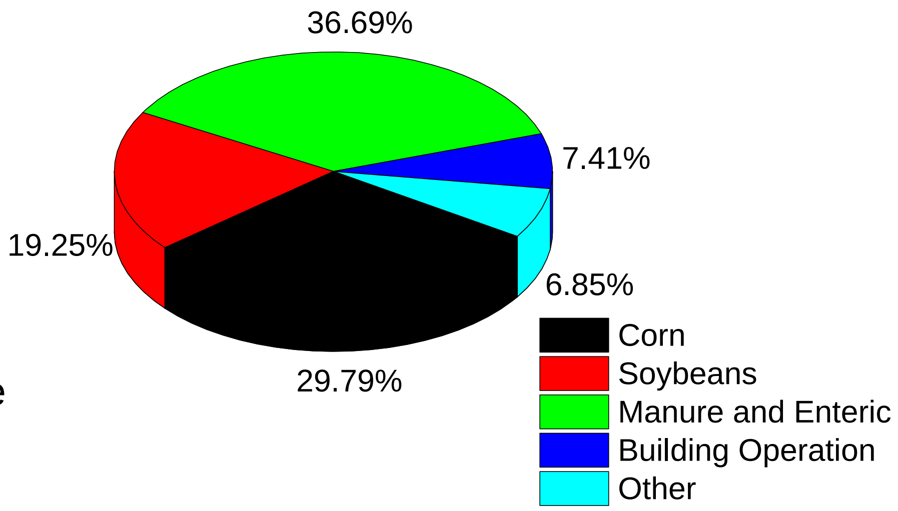
Tallaksen, 2016

Greenhouse Gas Emissions

Major GHG Emissions for Swine System

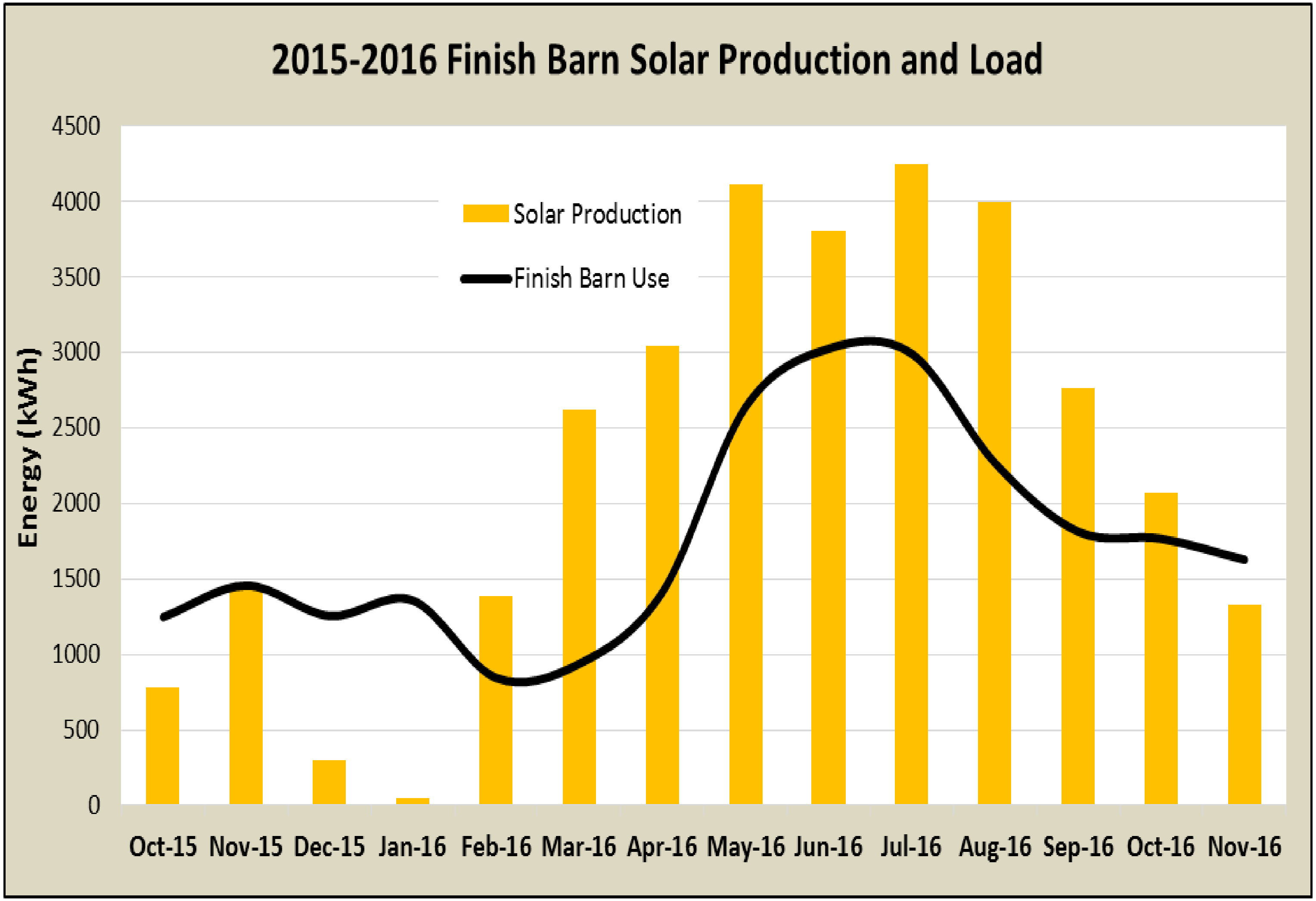
(Using IPCC 2007 GWP100a Method)

- Total emissions are roughly 2.2 kg CO2 per kg pork.
- Enteric emissions & manure are greatest single area, but would be hard to significantly reduce.
- Feed production emissions are roughly 50% of the swine emission
- Building operations emissions are an easy area to improve, but make up a small part of the overall emissions profile.



Tallaksen, 2016

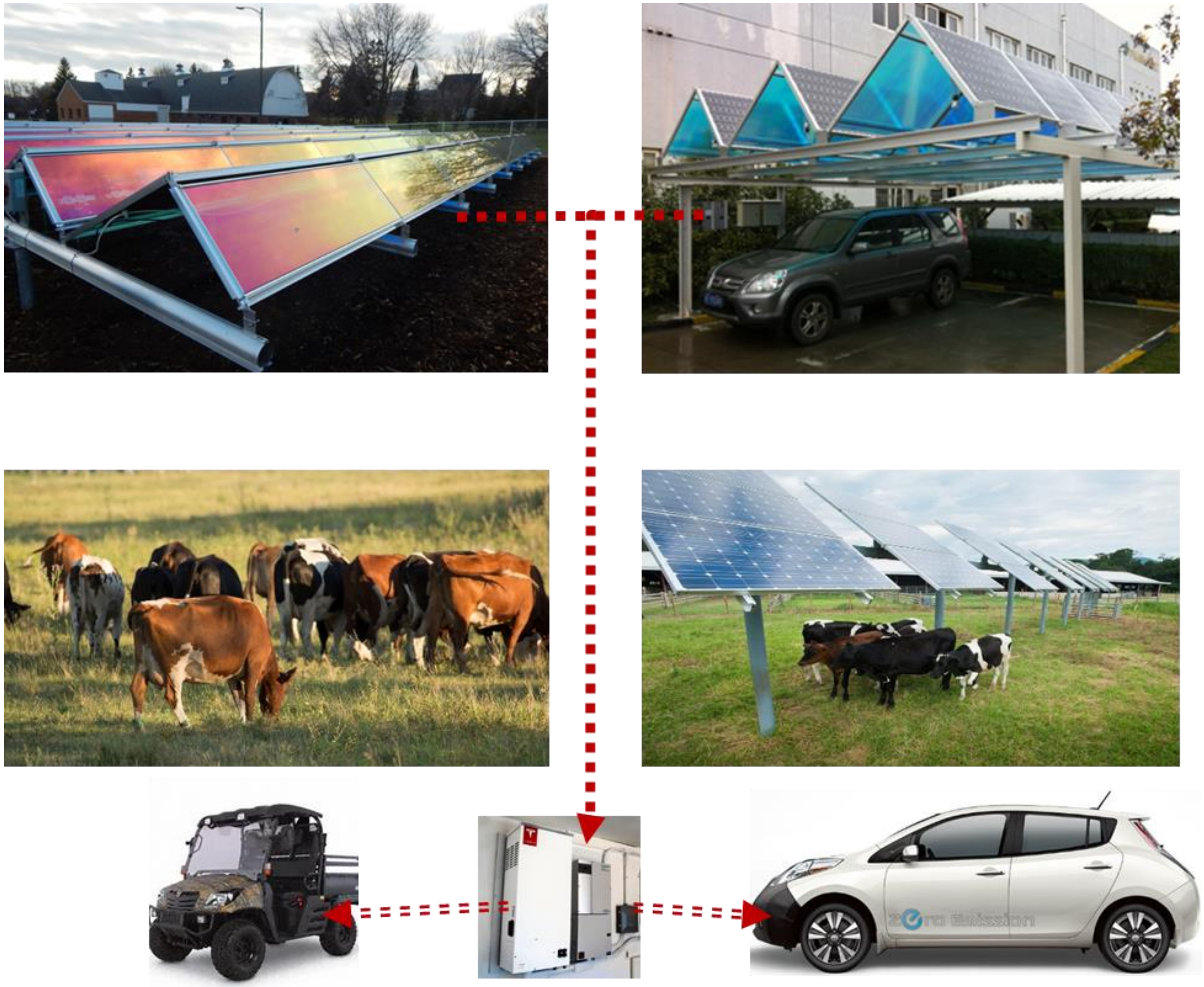
WCROC 27 kW Solar PV System on Swine Finishing Facility



WCROC 27 kW Solar PV System on Swine Finishing Facility

December 22, 2016

Multi-benefits



Take Home Message:

- ✓ Energy efficiency upgrades can have a short-term return-on-investment
- ✓ A solar PV system may be financially viable for your swine farm
- ✓ State, federal, and utility grants and incentives are available
- ✓ Reputable contractors are available to remove complexities
- ✓ U of MN energy research is helping to lower costs and serve as an unbiased source of information

Renewable Energy

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