

# STEVE MOLENAAR

## Willmar Area Climate Action Group



The **POWER** of MINNESOTA

Solar can easily power *and*  
heat your home



# What is your annual kilowatt usage / goal?

- Handy online calculator from
- the Department of Energy:
- <https://pvwatts.nrel.gov/>

## SYSTEM INFO

Modify the inputs below to run the simulation.

DC System Size (kW):

17.5



Module Type:

Premium



Array Type:

Fixed (open rack)



System Losses (%):

10



Tilt (deg):

36



Azimuth (deg):

180



# See your projected kilowatt hours by month

## RESULTS



# 25,429 kWh/Year\*

System output may range from 23,876 to 26,233 kWh per year near this location.  
Click [HERE](#) for more information.

Month	Solar Radiation ( kWh / m <sup>2</sup> / day )	AC Energy ( kWh )	Value ( \$ )
January	3.13	1,541	153
February	4.04	1,756	174
March	4.70	2,187	217
April	5.59	2,426	240
May	5.41	2,423	240
June	6.08	2,597	257
July	6.58	2,789	276
August	6.00	2,591	257
September	5.63	2,390	237
October	4.08	1,864	185
November	3.24	1,463	145
December	2.87	1,402	139
Annual	4.78	25,429	\$ 2,520

# Alternate formula method

- <https://photovoltaic-software.com/principle-ressources/how-calculate-solar-energy-power-pv-systems>
- $E = A * r * H * PR$
- $E = 48 \text{ panels} \times 1.94 \text{ m}^2/\text{panel} \times 18.8\% \text{ module efficiency} \times 1679 \text{ kWh/m}^2/\text{year} \times 0.8 \text{ performance ratio}$
- $= 23,514 \text{ kWh/year}$
- 
- E = Energy (kWh per year)
- A = Total solar panel Area (m<sup>2</sup>)
- r = solar panel yield or efficiency(%)
- H = Annual average solar radiation on tilted panels (shadings not included) in kWh/m<sup>2</sup>/year from <https://www.nrel.gov/gis/solar.html>
- PR = Performance ratio, coefficient for losses (range between 0.5 and 0.9, default value = 0.75)

$PR = (1 - \text{Inverter losses (6\% to 15\%)}) \times (1 - \text{Température losses (5\% to 15\%)}) \times (1 - \text{DC cables losses (1 to 3\%)}) \times (1 - \text{AC cables losses (1 to 3\%)}) \times (1 - \text{Shadings 0\% to 40\% (depends of site)}) \times (1 - \text{Losses weak irradiation 3\% to 7\%}) \times (1 - \text{Losses due to dust, snow... (2\%)}) = \text{can range from 0.5 to 0.9}$



# Rooftop or Ground Mount?





# Get at least three quotes and choose

- Solar Spark Energy Consultants / Abaris EC LLC
- 17.5 kW DC, Ground mount, \$55,201.63, \$3.15 per watt
- \$55,201.63 - \$16,560.49 tax credit = \$38,641.14 our cost after tax credit
- Abaris EC can get as low as \$2.30 per watt for projects nearer 40 kW

## Other resources:

- Minnesota Solar Guide: <http://mn.gov/commerce-stat/pdfs/solar-directory.pdf>
- Clean Energy Resource Teams: <https://www.cleanenergyresourceteams.org/>

# Sign contract with Kandiyohi Power Coop

- RURAL ELECTRIC COOPERATIVE UNIFORM CONTRACT FOR COGENERATION AND SMALL POWER PRODUCTION FACILITIES
- THIS CONTRACT is entered into September 30, 2019, by Kandiyohi Power Cooperative and (homeowner).
- RECITALS
- The Qualifying Facility, (QF) has installed electric generating facilities, consisting of single phase PV system rated at 15.2 kilowatts AC of electricity.
- The Cooperative will buy electricity from the QF at at the average retail cooperative energy rate.
- The QF is responsible for the actual, reasonable costs of interconnection which are estimated to be \$600.00



# Apply for a building permit

- Electrical contractor = Abaris EC LLC, license EA004369, Phone (218)979-0254
- Description of project = 15.2 kW AC grid tied solar project, 48 modules, 2 x 24 on ground mount. Front modules installed 30" off ground, dimensions 83 ft x 9 ft, project cost \$55,201.63
- Property owner waiver signed acknowledging that I am acting as our own contractor and am exempt from the state license requirements.
- Include a site plan, basic wiring diagram and solar racking installation instructions.
- Pay the permit fee of \$806.08, (based on the project cost).
- The waiting period for the application is about 7-10 working days.

# Choose a panel manufacturer

- California's Energy Equipment Solar Equipment List, [https://www.gosolarcalifornia.ca.gov/equipment/pv\\_modules.php](https://www.gosolarcalifornia.ca.gov/equipment/pv_modules.php), includes over 300 manufacturers.
- But...
- Renewable Energy Test Center's PV Module index report, available at: <https://retc-ca.com/pv-module-index/>, helps narrow down the choice.
- Their report concludes, "For 2018, two manufacturers are recognized for demonstrating high achievement across indicators in all three categories of Reliability, Performance, and Quality. RETC congratulates **Longi Green Energy Technology** and **Panasonic** for their respective performance in the 2019 edition of the PV Module Index".



# The Installation

## Vermeer PD10 Pile Driver



## Building the racking





# Finishing up

## Attach Panels



## Install the final Panel



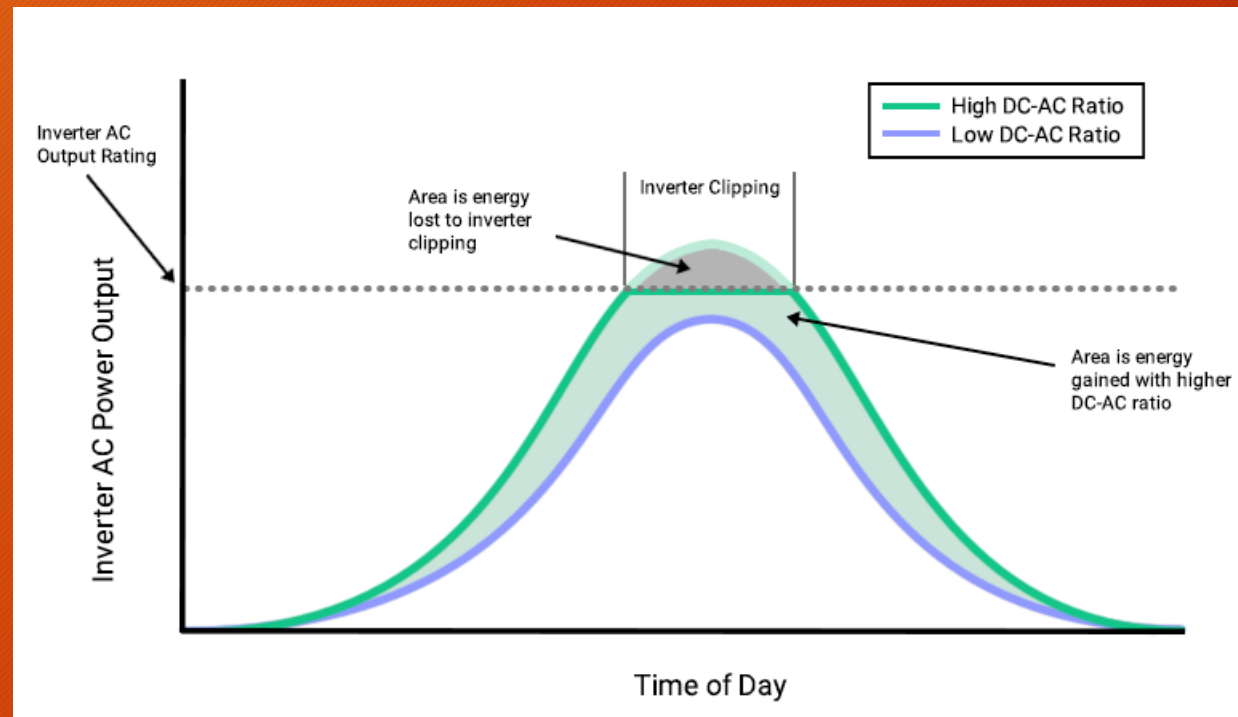
## Connect the Wiring





# DC/inverter AC wattage ratio & Clipping

Each of our two inverters is connected to 24 solar panels x 365 watts = 8,760 watts total. The inverter size is 7,600 watts for a ratio of  $8760/7600 = 1.15$ . Recommended ratios range from 1.15 up to about 1.6. This graph shows how at mid-day, wattage in excess of the inverter's rating is not used, or "clipped".



# Line Side or Load Side Connection?

- We chose to connect our solar panels to the load side of Kandiyohi Power Coop's meter. With this choice, we pay the usual \$0.099 to \$0.119 retail rate per kW hour from the Coop. Any surplus we produce makes the Coop's meter run backward and that surplus is sold to the Coop at the Average Retail Cooperative Energy Rate, (ARCER), \$0.0995 /kWh in 2019.
- Coop fees: \$41 per month meter fee plus if we produce more than we use, the Coop will charge us a grid access fee of ((size of system in kW, ie. 17.5kW) - 3.5 kW) x \$1.65 or \$16.00 per month, whichever is less.



# Going one step further: Heating without fossil fuel, using a geothermal heat pump.

Toro Horizontal Boring



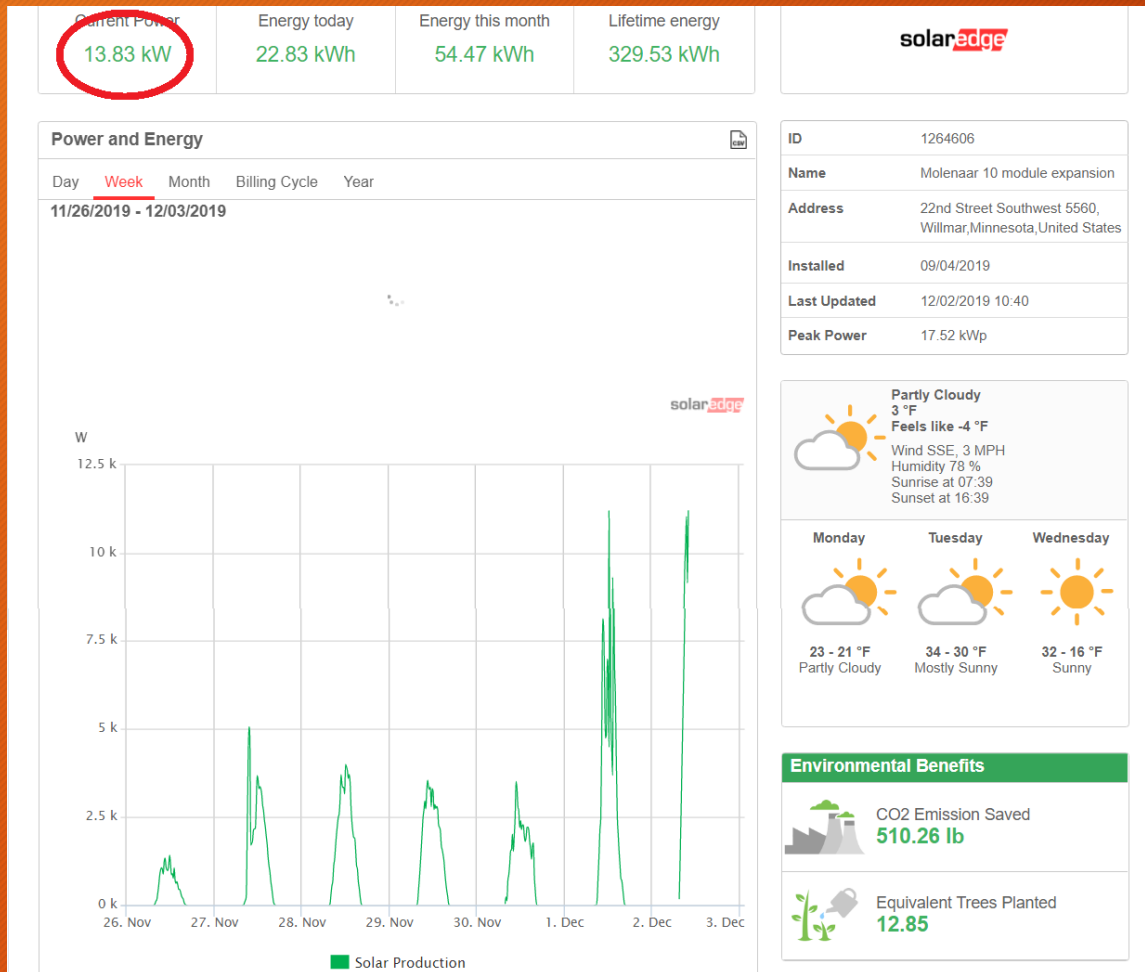
Heat exchange loops



WaterFurnace geothermal heat pump from B & B Electrictrical Contractors, Minneota, MN



# SolarEdge App for Monitoring Solar Panels



10:45 AM on December 2, 2109  
Mostly sunny conditions

13.83 kilowatts being  
generated



# WaterFurnace App for monitoring the heat pump

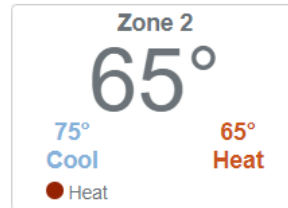
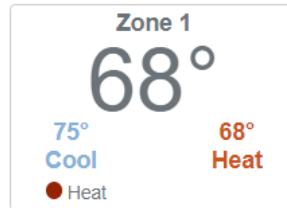
## CURRENT STATUS:

11:00 AM Mon 12/2 Central

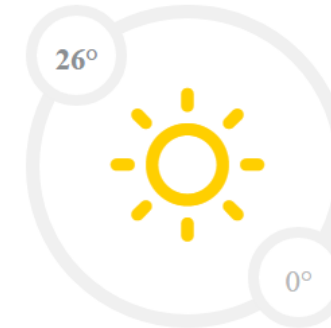


Heating Speed 3

## THERMOSTAT SUMMARY



## WILLMAR, MN

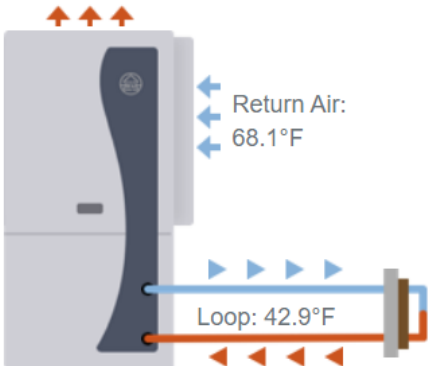


Current Temp: 13°

## EQUIPMENT SUMMARY

Series: 7 Series  
Model: NVV048A111CTR0KN  
Serial #: 191100092

Supply Air: 82°F



Humidity  
Level: 45%



Comp Speed  
3



Fan Motor  
6



Aux Elect Heat  
OFF

## CURRENT ENERGY USE



Compressor  
753 W



Fan Motor  
168 W



Total Unit  
Energy  
1106 W



Aux Elect Heat  
0 W



Loop Pump  
185 W

Tuesday		33° 19°
Wednesday		33° 23°
Thursday		33° 16°
Friday		19° 8°
Saturday		38° 18°

Powered by Dark Sky

11:00 AM  
December 2, 2019  
Outside temp 13°F

Only 1.106  
kilowatts of the  
13.83 kilowatts is  
being used to heat  
the house

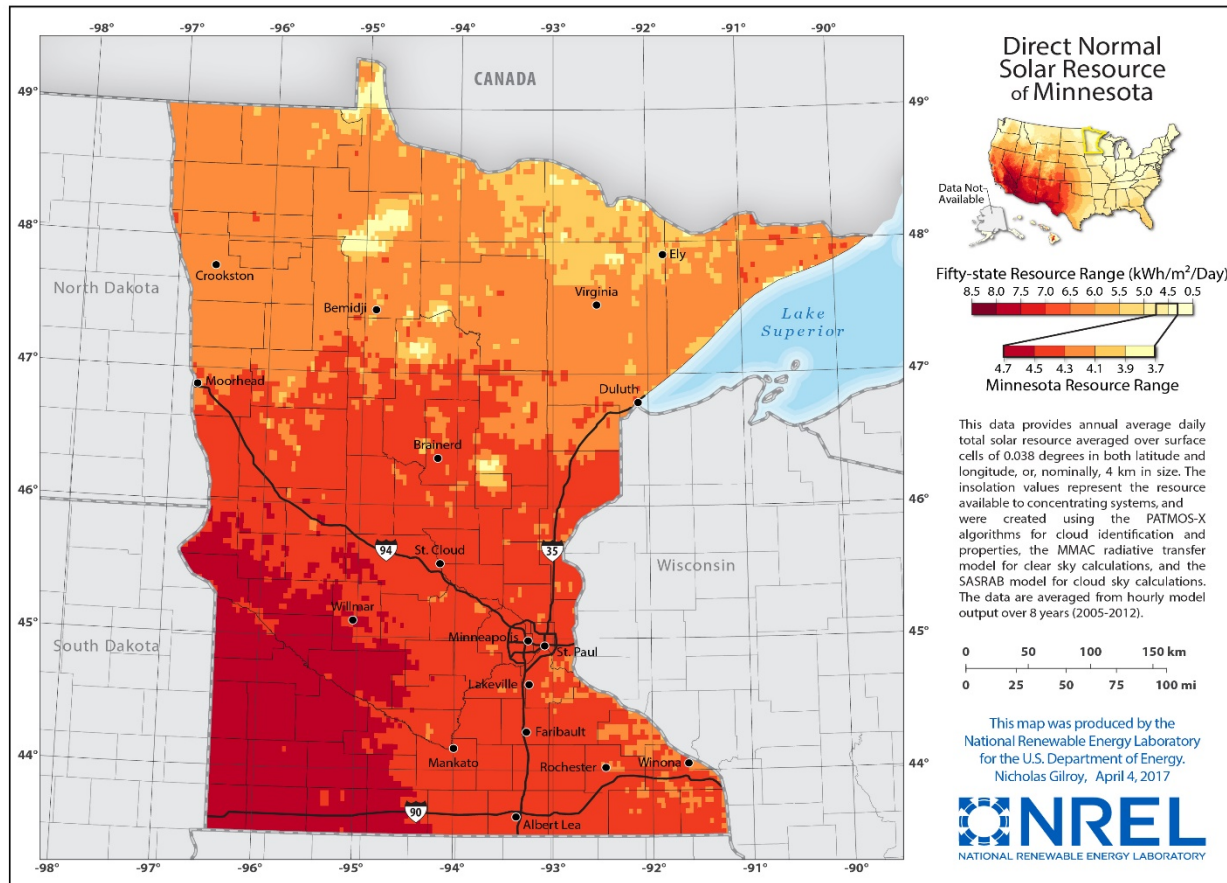
## Fun Fact

- The amount of solar energy falling on a square meter of the Earth's upper atmosphere is called the solar constant, equal to about 1400 watts per square meter, and which is enough to illuminate 100 LED light bulbs continuously.



# Minnesota Solar Resource Map

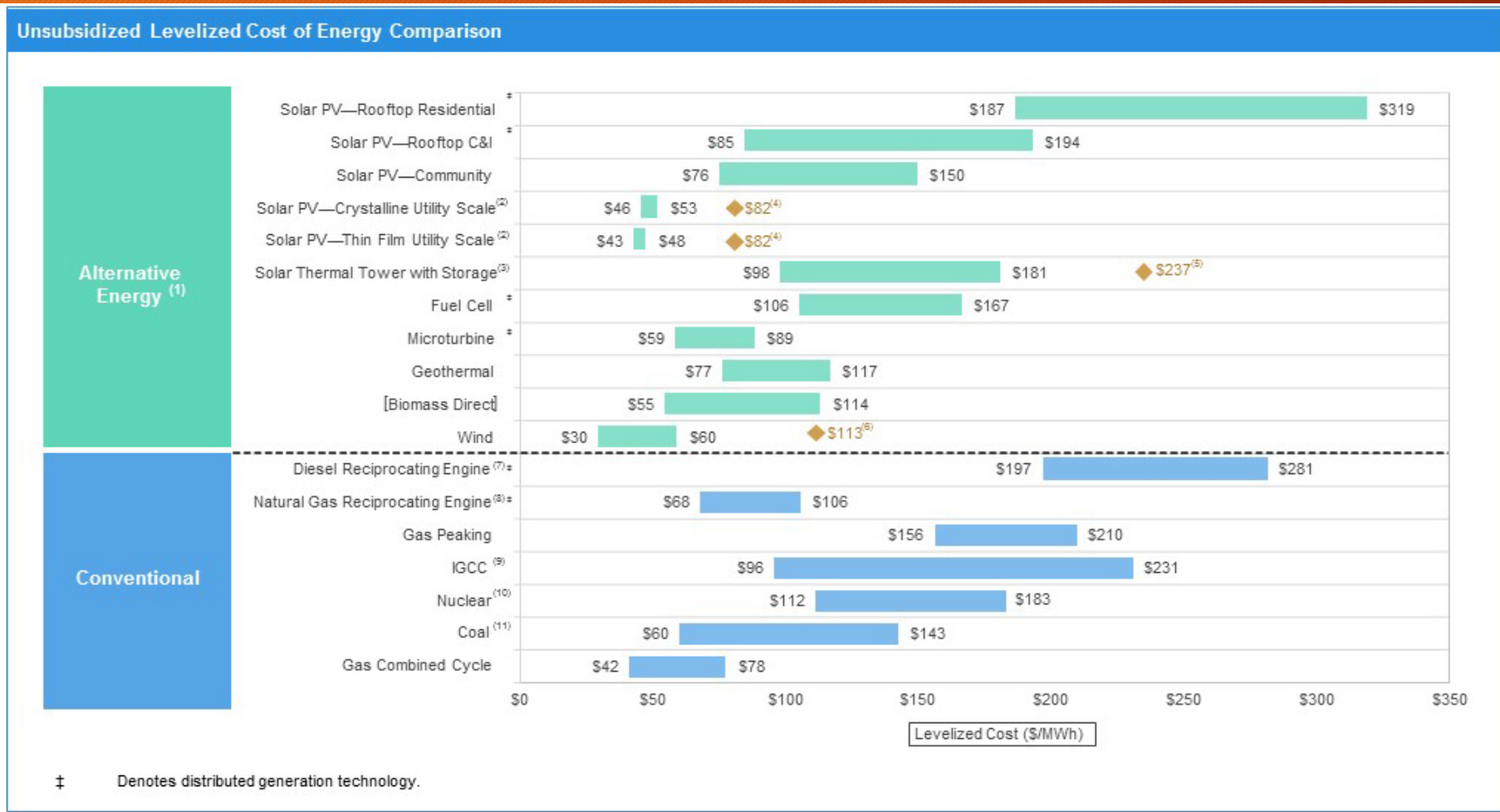
<https://www.nrel.gov/gis/solar.html>



Source: National Renewable Energy Laboratory

# Solar and wind are cheaper than coal!

<https://www.lazard.com/perspective/levelized-cost-of-energy-2017/>



Costs per  
Megawatt  
Hour



# *The* **POWER** *of* **MINNESOTA**

Our energy. Our communities. Our stories.

**FILM SCREENING**  
**+ COMMUNITY CONVERSATION**  
IN WILLMAR

Saturday, December 7, 2019 | 1:30pm  
Willmar Public Library

