

Net Zero Residence

**Low Annual Cost
Reliable and Pollution-Free**

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Retired Power Systems Engineer

TOPICS

- High Efficiency Construction
- Solar Electric System
 - Solar System Cost
- Geothermal Wells
- Electric Heat Pump
- Radiant Floor Heat
 - Geothermal System Cost

Stretch Code

- A part of the Mass Green Communities initiative
- Part of the Building code since July 2009
 - Appendix 115AA
- Provides a more energy efficient alternative to the standard provisions in the code
- 180 Massachusetts municipalities have adopted the stretch code as of October 2016
 - 12 in Berkshire county

HERS Index

- High Efficiency Rating System
- Required for new construction for towns that have adopted the stretch code
- A scale from 150 to 0 where:
 - 150 --- a more energy consuming home
 - 100 --- rating of a new home (standard construction)
 - 0 --- a zero energy home
- Our house is rated at:
 - 47 without solar system
 - 15 with solar system

Compliance Requirements

- Energy STAR Thermal Bypass checklist
 - Air barriers
 - Walls adjoining exterior walls
 - Floors between conditioned spaces
 - Attic/ceiling interface
- Energy STAR requirements for windows/doors/skylights
- Building air tightness test
- Residential energy compliance certificate
- HERS rater, inspections, testing and paperwork provided by Center for EcoTechnology (CET)

High Efficiency Construction

- Need to pass blower door test (stretch code)
- Insulation
 - Walls 2x6 R26
 - R21 fiberglass, then R5 DOW Super Tuff R 'blueboard'
- Ceilings
 - R38 and R49 wherever possible
 - R38 between joists, then R11 opposite direction
- Box Sills, R32
- Foundation, R10 to top of sill plate
- All sill joints and wall/ceiling joints caulked
- High efficiency windows and doors



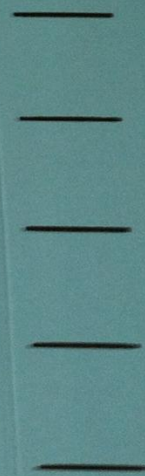


R21 insulation, caulked sill

IT IS THE BUYER'S RESPONSIBILITY TO ENSURE PRODUCT USE IN ACCORDANCE WITH ALL APPLICABLE CODES AND REGULATIONS. CAUTION: This product is combustible and shall only be used as specified by the tool building code with respect to flame spread classification and to the use of a suitable thermal barrier. SEE ICC-ES ESR-908, Authored by IN-ENTER TESTING SERVICES. For MSDS and more information, www.toolbuildingproducts.com and/or call 1-888-580-BLUE2990, or contact your local building inspector in an emergency call 1-888-638-4440.

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Insulation



WORLDWIDE PARTNER

Normal Board Thickness
R-VALUE

1/2"	2.05
3/4"	3.07



Blower door test

Electric, Heat and Hot Water

- Provide electrical requirements by way of a solar power generation plant
- Provide heating requirements by way of a geothermal well, heat pump, storage tank, and circulating water radiant floor
- Provide hot water by way of a hybrid (electric / heat pump) hot water heater
- Receive on-going financial benefits:
 - Don't pay for electricity you produce and use
 - Receive credit for electricity you produce and don't use
 - Receive payment for electricity produced via SRECs
 - No oil or gas payments
- Limited annual cost for electric, heat and hot water

What is an SREC?

- Solar Renewable Energy Certificate (SREC)
- A tradable certificate that represents all the clean energy benefits of electricity generated from your solar electric system
- SREC's are issued to you regularly as your solar system generates each 1000 kiloWatt hours
- A 10 kW system will generate almost 12 SREC credits each year (~\$4,200)

Solar Plan

- We wanted a system to exceed our use
 - Our use is modest and we can allocate surplus to another account
- Desired a ground mount system
 - Ease of maintenance (thought we'd own it)
 - Had plenty of room in the field
 - Just didn't want it on our roof
 - Could 'sweep' off snow if needed
- A good choice since our house burned down

Electrical Power Flow



Power used = Power from Array + Power from Electric company – Power to Electric company

Notes:

1. Electric company charges for the “NET” power sent to the house (power from Electric company minus Power to Electric company)
2. Power to and power from Electric company is the same rate (~\$0.155/kWHR)
3. Electric company does not have visibility into what the house “uses”
4. Array production is metered and compensated for via SRECs (~\$0.35/kWHR)

Solar panels

- Convert the sun's radiant energy to
- 30 Volts direct current electrical power

Solar Panel(s) (40)

Sunmodule SW 240

- Maximum power 240 Watts
- Max operating voltage 30.6 Volts
- Max operating current 7.87 Amps
- Open circuit voltage 37.6 Volts
- Short circuit current 8.22 Amps
- Operating temperature -40°C to 85°C

- Cells per module (panel) (10x6) 60
- Cell type Mono crystalline
- Cell dimensions 6.14 in x 6.14 in

- Front Tempered glass EN 12150
- Frame Black anodized aluminum
- Size 37.44 in x 65.94 in 1.22 in
- Weight 46.7 lbs.
- Warranty 25-year
- Performance degradation 0.7% p.a.



Inverters

- Convert 30 Volts direct current energy to
- 240 Volts, single phase, 60 cycle alternate current power
- Synchronize themselves to the power grid (Electric company or backup-generator)
- Provide open circuit output when grid goes down (power is lost)
 - Required by Electric company in order to get approval to connect to their grid

The solar array is not a backup system

Inverter(s) (40)

Microinverter M215

- Input power 190-270W
- Max input voltage 45V
- Peak power tracking voltage 22-36V
- Operating range 21-36V
- Min / Max start voltage 22V / 45V
- Max DC Short circuit current 15A
- Max input current 10.5A
- Max output power 215W
- Nominal output current 0.9A
- Nominal voltage / range 240V / 206-269V
- Nominal frequency / range 60.0 / 59.3-60.5 Hz
- Max units per 20A circuit 17
- Efficiency 96%
- Off power consumption 46mW
- Operating temperature -40°C to 85°C
- Size (WxHxD) 6.8" x 6.45" x 1.0"
- Weight 3.5 lbs.
- Warranty 25-year



Distribution

- System function

- connects / disconnects
 - solar system to
 - electric company (Electric company) power grid
 - electric meter changed to a “NET-meter”

- Components

- PV junction box - mounted on the array
- PV meter - mounted outside on the garage near the array
- PV disconnect - mounted outside on the garage near the array
- PV load center - subpanel mounted inside the garage
- AC disconnect - main panel mounted inside the house
- Net meter - mounted outside on a pedestal

Design – satellite view



Monitoring system components

- 120 Vac 'array-sourced' outlet
- Envoy controller / monitor
 - Collects array data over the 'power-line'
- Connected to the internet
- Web-based data collection and analysis system

Enphase Envoy Communications Gateway

- The networking hub connecting every module and microinverter in the solar array to the internet.
- The Envoy uses advanced powerline communications technology to connect to each microinverter without additional wiring or wireless configuration. System owners can easily check the status of their solar system using the Envoy's LCD display, or get more detailed information through the Enlighten website

Enlighten Website features

- Measures performance of each panel
- Panel and system power production (Watts)
 - daily, past 7 days, custom range
- Panel and system energy production (kWHrs)
 - daily, past 7 days, month to date, lifetime, custom range
- Reports
 - Site Energy Production
 - Site Recent Power Production
 - Monthly Energy Production
- Environmental benefits 'data'
 - Carbon Offset

Solar Project Cost

plan and actual

- System Cost \$40,078
- Federal Credit (\$13,824)
- State Credit (\$2,400)
- Contracted amount \$23,854 - Plan
- Other expenses \$ 698 (transformer, trenching)
- Tier credit (\$1,920)
- Referral credit (\$ 250)
- \$22,382 - Actual
- What we'll save (plan to save)
 - \$1,700 Electric bill(s) reduction (annually)
 - \$2,600 Solar Renewable Energy Credits (annually)
- 5.2 year pay back period
- After that, continue annual savings

Solar Installation

Picture Tour

System layout for the footings

Footprint 8' by 68'

Footings are ten galvanized screws



Solar Installation

Picture Tour

Galvanized screws - 6' 10" long



Foundation Supports – in place





Foundation Supports – in place

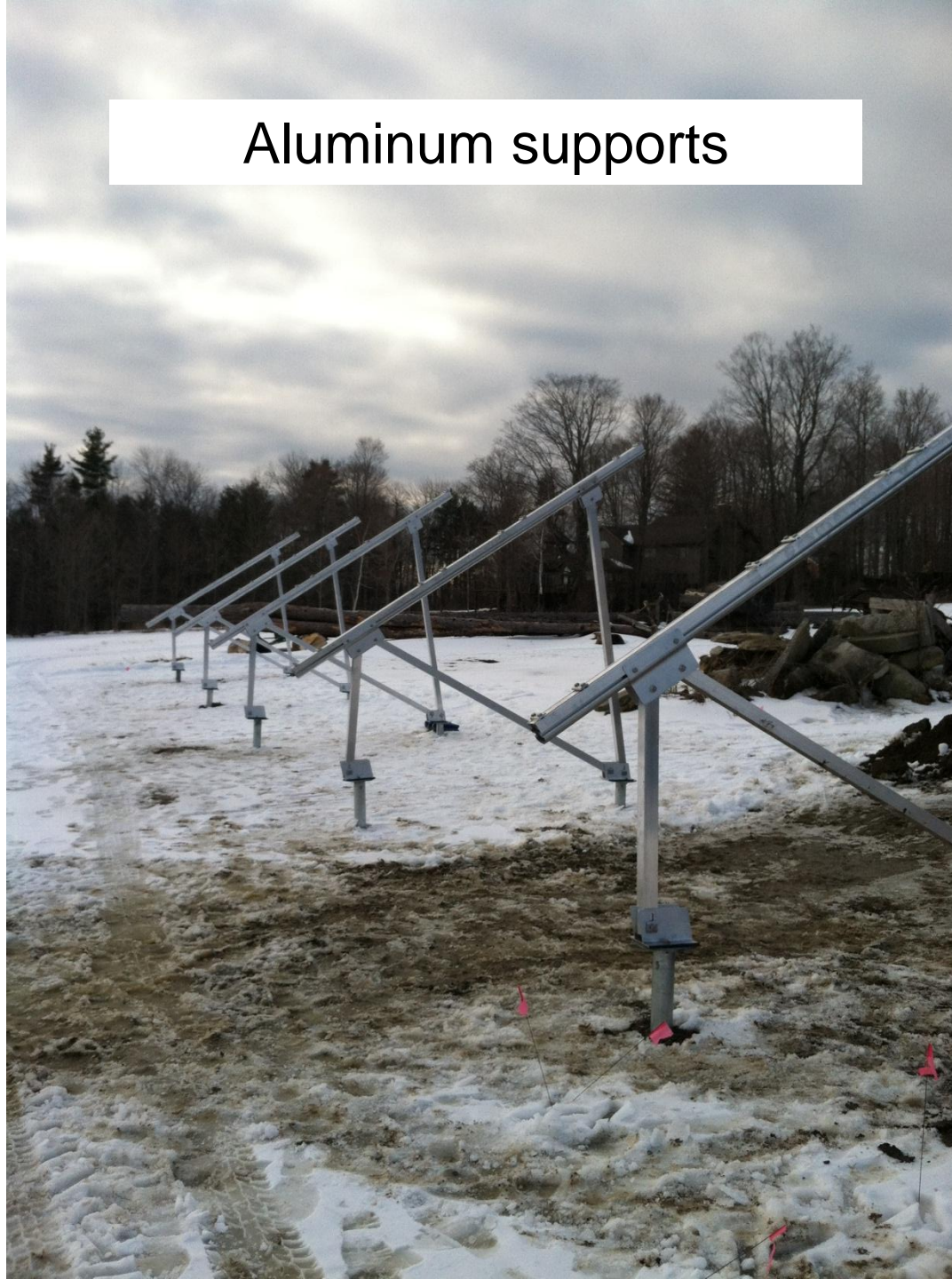
Solar Installation

Picture Tour



Close-up of screws

Aluminum supports





Installation in process



Installation complete - looking north



Installation complete – looking west



Installation complete – looking south



Panel

Panel Fastener



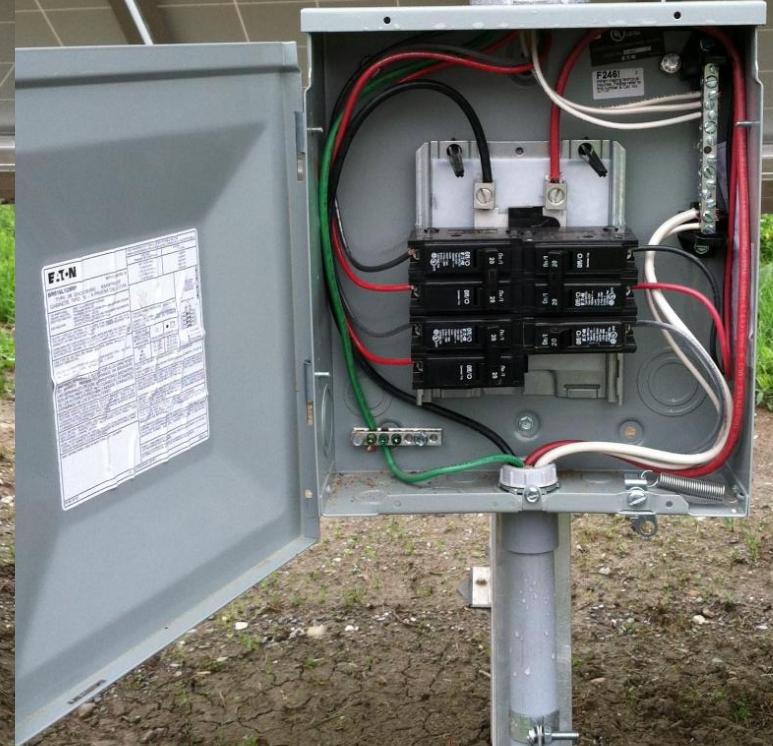
Panel Fastener



Inverter

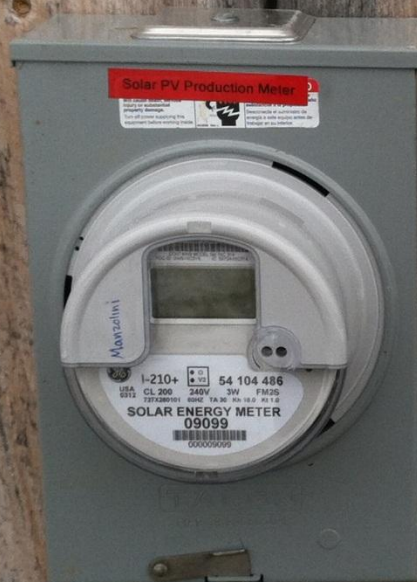


PV junction panel





Production meter



PV disconnect switch



Sub Panel in Garage



Sub Panel in Garage

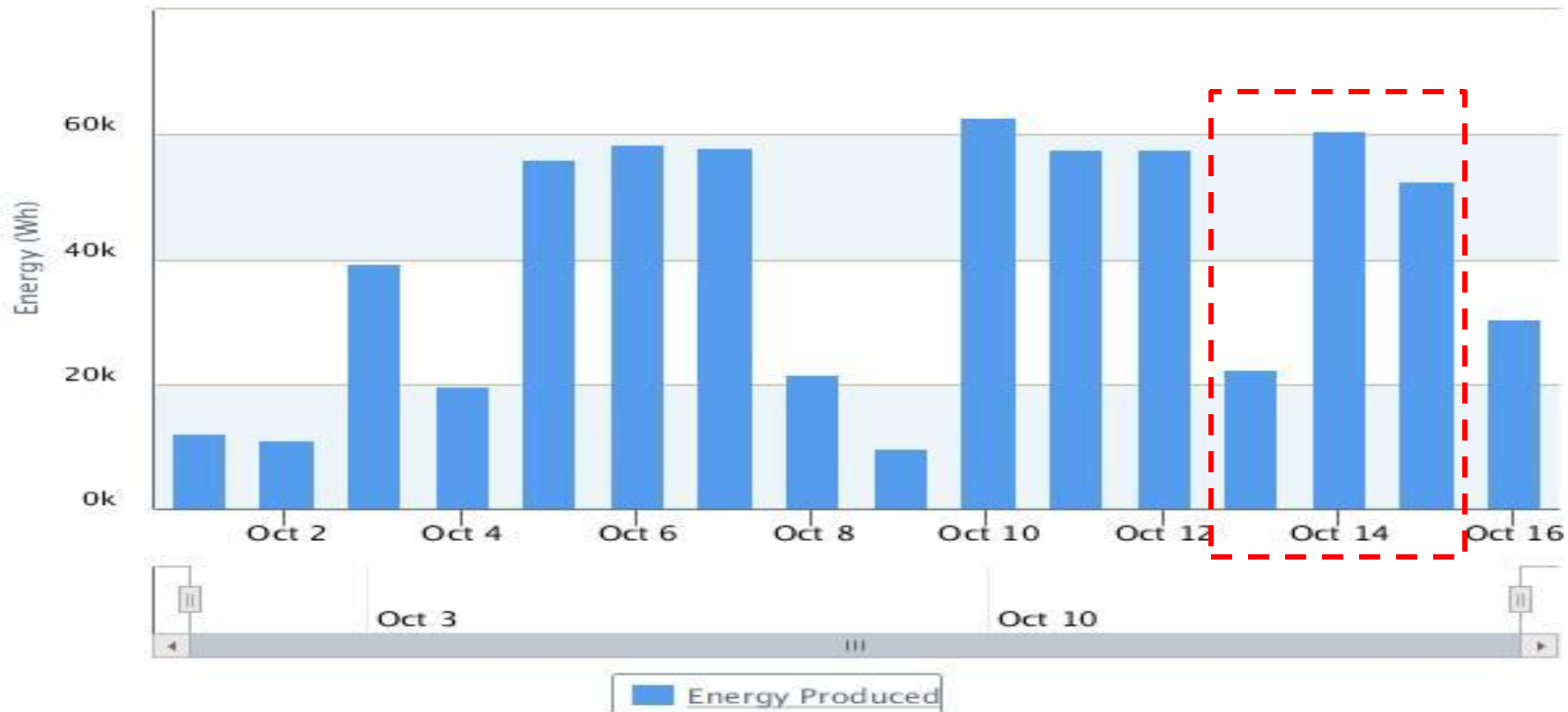




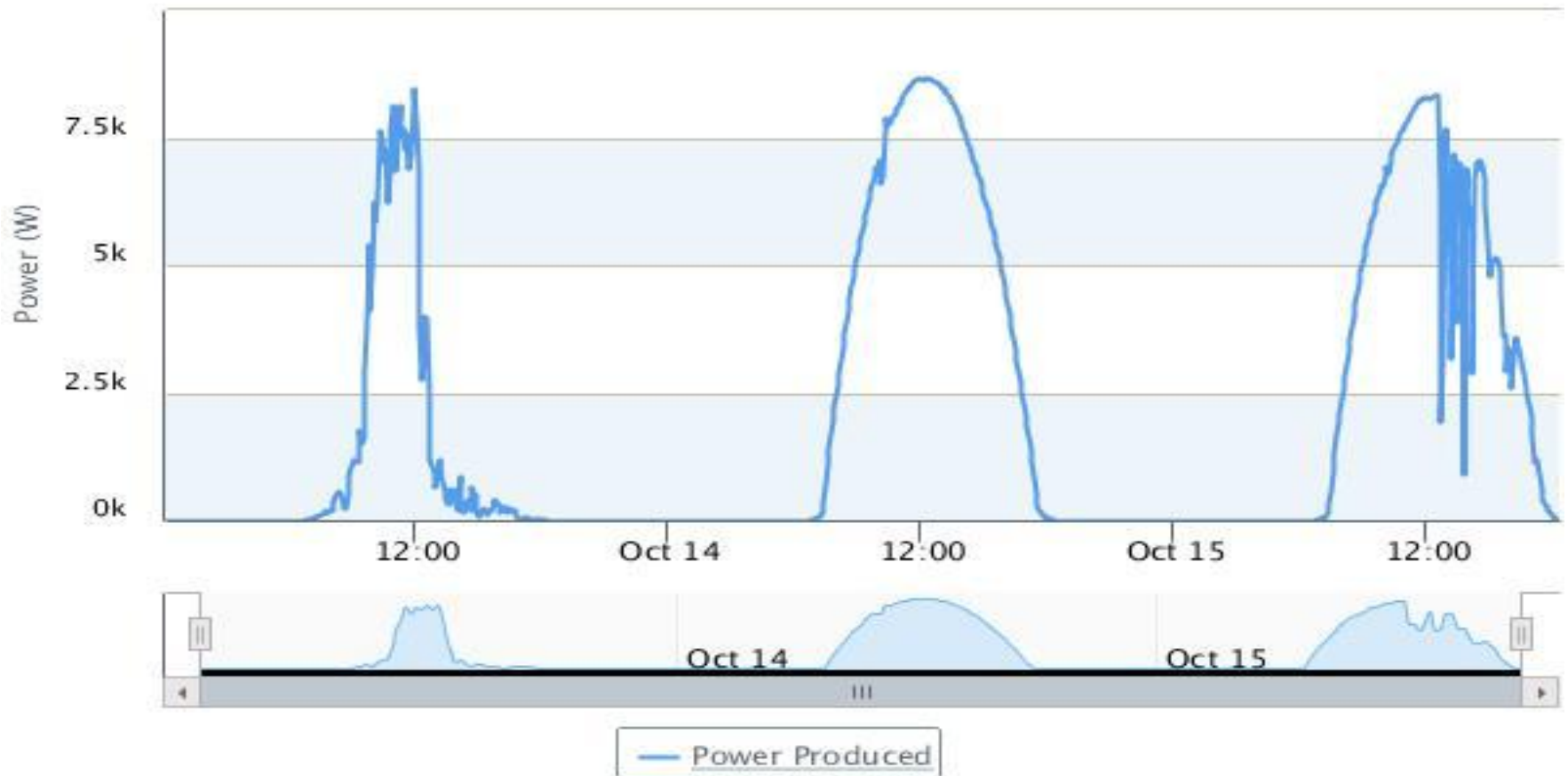
Envoy Communications Gateway in Garage

Production results

Month to date

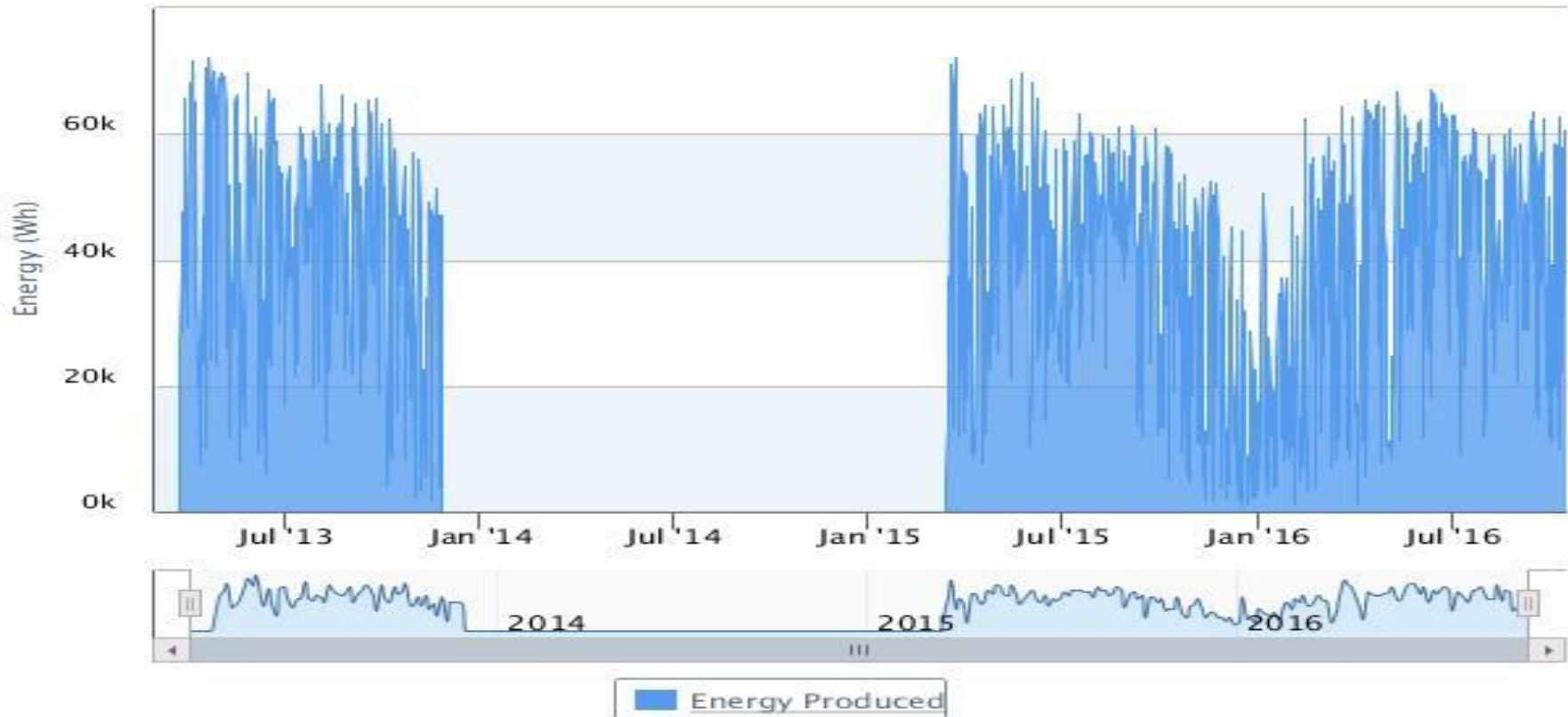


Sample of different days



Production results to date

System turned on March 25, 2013



ROGER W MANZOLINI

SOURCE

Due Date	Total Amount Due
Nov 5, 2016	- \$1,237.15

Statement date: Oct 11, 2016

Customer name key: MANZ

Account number: 54652376005

tion
659-6326 (anytime)
ersource.com
erviceWMass@eversource.com

omers:
1-877-659-6326
ngfield area

at www.eversource.com
888-783-6618

plier is

-0270

Electric Account Summary

Amount due on Sep 12	- \$1,214.85
Balance Transfer Sep 12	\$53.19
Balance Forward	- \$1,161.66
New Charges/Credits	
Delivery Services	- \$75.49
Electricity Supply Services	\$0.00
Total new charges	- \$75.49
Credit Balance	- \$1,237.15

Detail for Service at:

725 CANAAN RD , RICHMOND MA 01254-5122

Service reference: 915843008

Billing cycle: 06

Your meter reading for meter # 893238642

For billing period: Sep 9 - Oct 7 (28 days)

Next read date on or about: Nov 7, 2016

Actual reading on Oct 7 , 2016 purchases 11801

Actual reading on Sep 9 , 2016 purchases - 11361

Billed usage = 440

Your meter reading for meter # 893238642

For billing period: Sep 9 - Oct 7 (28 days)

Next read date on or about: Nov 7, 2016

Actual reading on Oct 7 , 2016 sales 28632

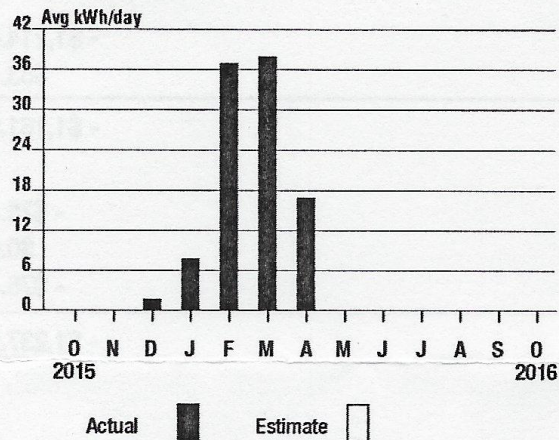
Actual reading on Sep 9 , 2016 sales - 27668

Billed usage = 964

Account number: 54652376005

Average usage in Oct 2015 (46 F) 0 kWh

Average usage in Oct 2016 (53 F) 0 kWh

Energy Profile**Delivery Services Detail**

RATE R1

Customer Chrg

\$6.00

Net Generation Credit

524.00KWH x \$0.155520

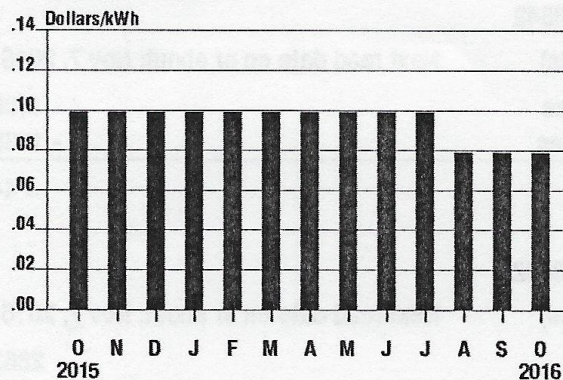
- \$81.49

Subtotal

- \$75.49

Generation Detail

RATE R1 - BASIC FIXED

Generation Rate







Installation in process







North well 300 feet deep



Both wells tied in parallel



Connections via heat fusion
in process





Tied connections into house





Service view









Climate panel installation
Glued and screwed

Straight panels

End panels

By-pass panels







Pex tubing installation







Tile over radiant floor

Three closed loop systems

- Wells (4 degree gain)
 - 49 degree water sent into the well loop
 - 53 degree water returned from the well loop
- Heat pump converts the energy in the 4 degree differential ground loop to maintain the radiant floor loop temperature of 102 degrees
- Radiant floor loop (4 degree loss)
 - 102 degree water sent into the loop
 - 98 degree water returned from the loop

Heating System Cost

• Wells	\$16,723
• Heat pump and controls	\$19,218
• Radiant floor	\$22,000
• Electrical	\$2,938
• System cost	\$60,869
• Federal credit	(\$20,106)
• State credit	(\$2,400)
• Mass geo energy award	(\$4,850)
• Mass Save incentive	(\$1,250)
• Total cost	\$32,263
• Estimated annual savings	\$2,800
• 11.5 year pay back period	
• After that, continue annual savings	

The End