



Colorado Renewable Energy Society
2012 Sustainable Living Home Tour

Living Without Fire – Just the Sun
Illustration of a way to retrofit a 1974 home



**Colorado
Renewable
Energy
Society**

Your Renewable Energy Resource



Sustainable Living Home Tour

29 September 2012

6097 S. Jackson St.

Hosts: Milt Hetrick, Gail Collins-Ranadive

**“Never doubt that a small group of thoughtful, committed citizens can change the world;
indeed, it's the only thing that ever has.”**

...Margaret Meade

Our Motivation For Change

Bad News

- Some current human behavior is not sustainable
 - We 7 billion humans are living off one-time-only finite ancient energy resources. This is not sustainable.
 - All other life on Planet Earth has evolved to live off current (or recent) sunlight and recycle every atom of material resources.
 - Humans can learn how to do this too.
 - We are “mine-ing” rather than “our-owe-ing” earth’s finite resources. This is not sustainable.
 - We “consume” resources rather than “borrowing / returning” them. This is not sustainable.
 - We are creating things (chemicals, weapons, etc.) that do not promote life (i.e. are toxic). This is not sustainable.
 - We discard toxic by-products and dump them into the air, waterways, oceans, landfills where it harms both human and non-human life. This is not sustainable.
 - We continue to live within social systems (political/economic/legal/educational/spiritual systems) that promote violence (i.e. violence is any action that prevents life from reaching its potential). These human-created systems influence us to make unsustainable choices and to behave in a manner that is not in right relations with all Life – not in right relations with our planet’s ecosystem. This is not sustainable.
- We are not leaving our planet a better place for future generations – but we could.
 - To leave our planet in worse condition than we found it is unethical/immoral with respect to all future generations – because we can do better.

We can change how we live. We must change how we live. Now

Our Motivation For Change

Good News

- If any living species can change and transition to a sustainable way of living, it is us humans
 - We are extremely gifted observers
 - We are able to extend our observations to make predictions
 - We are extremely adaptable to a changing environment
 - We are able to use observations & predictions to avoid death and destruction – to seek physical and moral high ground
- There is no known physical law/ reason why humans can't thrive (and continue to grow in awareness & consciousness) on this planet for at least 500 million more years – that's 20,000,000 more generations.
- There are many people (Paul Hawken calls them the “Blessed Unrest”) who can see today's injustices, unsustainable behavior and future challenges. These people are exerting their individual and collective energy to bring about a global transition to a way of life where we homo sapiens are in right relations with all life on our common planet. There is hope because there is consciousness.
- We know that a sustainable planet is also a peaceful planet – where peace is defined as the absence of violence and the presence of opportunity. We still have enormous opportunities for change - assuming we use the time and remaining reserves of our one-time-only ancient stores of energy to make that transition.
- We can retain our individual freedoms (and hence our ability to be creative) if we self-impose responsible behavior that is sustainable and life serving. Freedom and responsibility are one.

We can change how we live. We must change how we live. Now

Hydrocarbons Are Too Valuable To Burn

“Burning petroleum as a fuel would be akin to firing up a kitchen stove with bank notes.”

...Dmitry Ivanovich Mendeleev, 1877

D.I. Mendeleev, Russian chemist and father of the periodic table of basic elements, recognized the importance of petroleum as a source from which to make valuable carbon compounds and not as a fuel to burn/consume. In 1876, on visiting the oil fields of Pennsylvania and Azerbaijan, he supposedly made the above remark.

Reference: “*Chemistry: The Molecular Science, Volume I*”,
John W. Moore, Conrad L. Stanitski, p 546.

Today we know many other uses of petroleum including: pharmaceuticals, plastics, and most recently carbon fiber for light weight materials – materials essential for aviation, aerospace, auto industry, and renewable energy technology (e.g. wind turbine blades are fabricated using carbon fiber composite materials).

If you don't like a "product" don't buy it

Examples of things we buy associated with things we don't like:

(Energy related examples)

- We buy Electrical Power (generated by burning coal, oil, municipal waste, etc.)
 - Yet we are upset about mountain top removal as a means of mining coal
 - Yet we are upset by the CO₂ (linked to climate change), coal ash (linked to asthma, etc.), mercury (linked to neurological damage of infants) that coal-fired plants dump into our common atmosphere
 - And there are alternatives!
- We buy Natural Gas/Methane (extracted from shale)
 - Yet we are upset about toxic chemicals that end up in our water and air associated with the fracking process
 - Yet we are upset by the methane that escapes during fracking and the CO₂ produced when we burn this so called "clean" hydrocarbon - both are greenhouse gases linked to climate change.
 - And there are alternatives!
- We buy Gasoline / Diesel Fuel
 - Yet we are upset about our dependence on "foreign" oil, drilling in pristine arctic regions, oil spills from deep ocean wells, ruptured pipelines & leaking tankers.
 - Yet we are upset by the CO₂ (linked to climate change) produced when we burn this hydrocarbon
 - Yet we are upset about the obscene profits of oil companies and the power they exert on our government for their own benefit(profit).
 - And there are alternatives!

Overview

The following provides a brief description of a personal experiment. We start with a house built in 1974 and in less than a year were able to retrofit it to transition from burning hydrocarbons (fossil fuel) to living off solar energy alone.

- The house is still “on the grid” so the utility company (Xcel) provides an energy “storage/banking” service but they do not have to burn more coal to generate our power needs
 - We generate an excess amount of electrical energy with Solar PV modules during the longer summer days and deposit this excess power in the “energy bank”
 - We draw from the “energy bank” in the evenings, and during the shorter winter days.
- The house does not burn any natural gas for heating
 - Heating and cooling are provided by a GeoExchange /GeoThermal Heat Pump Furnace powered by excess electrical power generated by the Sun
 - Hot water is pre-heated with the heat pump, and maintained with a standard electric hot water heater.
- The house provides electrical energy for local transportation (for trips less than 40-50 miles)
 - We use a plug-in hybrid vehicle that utilizes the excess electrical power generated by the Sun
 - For trips longer than 40-50 miles, the plug-in hybrid burns gasoline like a traditional internal combustion power car. (we get 40 mpg of gasoline on long trips)

Approach to Electrical Power

- Attempt to eliminate all burning of ancient hydrocarbons (See “Reinventing Fire” by Amory Lovins, Rocky Mountain Institute)
- Re-examine what we buy and look for alternatives
 - **Electrical Power**
 - Natural Gas
 - Gasoline
- Use the Buyer Choices available today

Example:

Start with electrical power.

– Today’s options:

- Buy electrical power from Xcel Energy [88% coal and natural gas; 10 % wind; 0.3% solar]

Yes
Yes

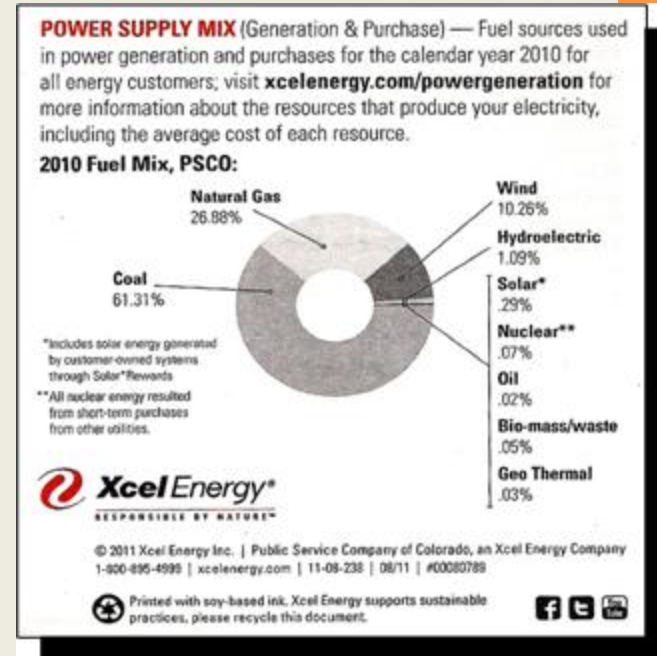
- Harvest our own sunlight (PV, wind, thermal)
- Conserve

– Conservation is necessary but not sufficient

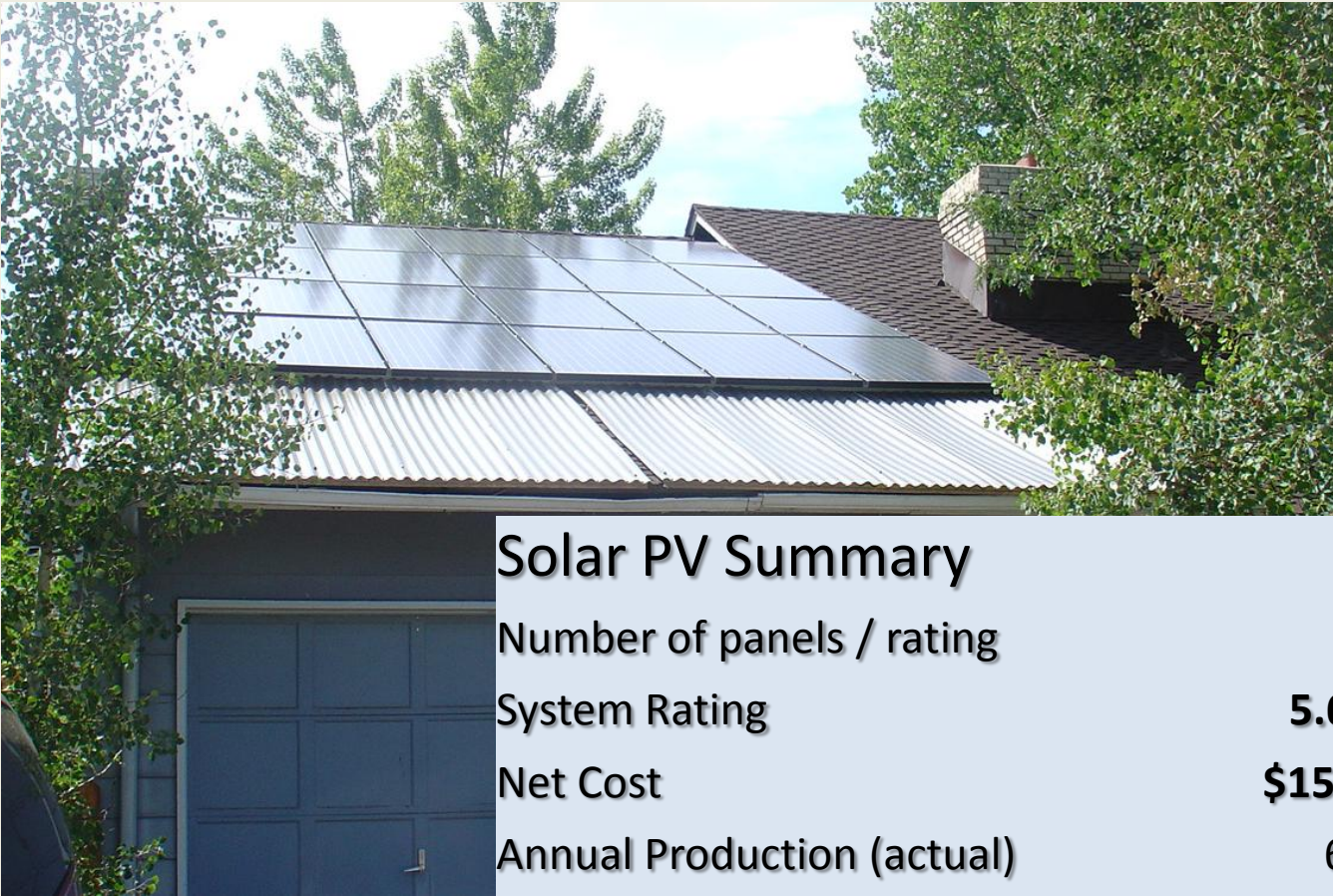
- » Conservation must not become a diversion – a smoke screen to make us feel good that we are “doing something.”
- » Conservation does not change our unsustainable behavior if that’s all we do

– Conservation must be accompanied by transition to renewable energy sources

- Do without



Solar Photovoltaic System



Solar PV Summary

Number of panels / rating	24 @235 W
System Rating	5.6 Kw
Net Cost	\$15,222 (\$2.70/W)
Annual Production (actual)	6800 kWh /year
Years of Operation (expected)	20+ years
Lifetime Production (expected)	136,000 kWh
Average cost/kWh for 20 years	\$0.11
Added Investment in Home	5%

Approach to Home Heating / Cooling

- Attempt to eliminate all burning of ancient hydrocarbons
(See “Reinventing Fire” by Amory Lovins, Rocky Mountain Institute)
- Re-examine what we buy and look for alternatives
 - Electrical Power
 - **Natural Gas**
 - Gasoline
- Use the Buyer Choices available today

Example: Space Heating and Air Conditioning, Hot Water

- Today’s options:
 - Buy natural gas from Xcel Energy [and support fracking] and burn it
 - Buy “Biomass” [recent hydrocarbons such as wood, dried dung, etc.] and burn it
 - Harvest sunlight and transform into thermal energy (Solar Thermal)
 - Excellent for Hot Water
 - Good for radiative space heating
 - Solar thermal cooling still being developed
- Yes • Exchange thermal energy with earth (GeoExchange/GeoThermal Heat Pump)
 - Excellent for Space Heating and Air Conditioning
 - Good for preheating water with electrical water heater
- Yes • Conserve (Insulate home, turn down thermostat, shorter showers, etc.)
 - Conservation is necessary but not sufficient
 - » Conservation must not become a diversion to make us feel we are “doing something.”
 - » Conservation does not change our unsustainable behavior if that’s all we do
 - Conservation must be accompanied by transition to renewable energy sources
- Do without

Geothermal Heat Pump – “Ground Loop”

- 1) Drilling two 300 feet deep holes about 4 inches in diameter to insert vertical heat exchange tubing. A horizontal ground loop may be an option for some homes.



Drilling first 300' deep hole



Drilling completed – now to suck up the mud

Geothermal Heat Pump – “Ground Loop”

2) Installing the heat exchange “ground loop”



Inserting U- shaped
black plastic tubing
300’ down into hole

Trenching to add manifold
connecting two boreholes



Trench backfilled –
ground loop now extends
underground into basement

Geothermal Heat Pump – Heat Pump

3) Installing the new heat pump furnace

New Heat Pump furnace
in place of
natural gas furnace



Ground Loop in basement
with two circulation motors



Connection of
Ground Loop
to Heat Pump



GeoThermal Heat Pump – Summary

- System Function
 - Central heating and air conditioning
 - Preheat hot water for electric water heater
 - GeoExchange/GeoThermal Heat Pump furnace replaces natural gas furnace and uses electrical power for solar PV
- System Technology
 - Mature heat exchange technology used in today's refrigerators
 - Exchanges thermal energy with the earth
- System Benefits
 - No Combustion / No Emissions / No need for natural gas
 - Gas line is now capped off



GeoExchange Heat Pump Summary

System Rating	4 Ton
Net Cost	\$19,199
Years of Operation (expected)	
Heat Pump	20+ years
Ground Loop	50+ years
Added Investment in Home	6%

Approach to Local Transportation

- Attempt to eliminate all burning of ancient hydrocarbons
(See “Reinventing Fire” by Amory Lovins, Rocky Mountain Institute)
- Re-examine what we buy and look for alternatives
 - Electrical Power
 - Natural Gas
 - **Gasoline**
- Use the Buyer Choices available today

Example: Transportation

– Today’s options:

- Buy gasoline / diesel fuel from Exxon Mobile, etc. [and support oil drilling, tar sands extraction, refining, etc.] and burn it

Yes

- Buy Plug-in Hybrid (350-400 mile total range)
 - Use the Electric Mode for local travel (40-50 mile range). Recharge using power from Solar PV
 - Use the Internal Combustion Engine (ICE) for extended range. ICE uses Gasoline today, but may run on biodiesel in the future.

- Buy All Electric Vehicle (Limited to 80-100 mile range)

Yes

- Conserve (walk, ride bicycle, public transportation,)
 - Conservation is necessary but not sufficient
 - » Conservation must not become a diversion – a smoke screen to make us feel good that we are “doing something.”
 - » Conservation does not change our unsustainable behavior if that’s all we do
 - Conservation must be accompanied by transition to renewable energy sources
- Do without

Local Transportation

- Excess electrical power from the solar PV system is used to operate a plug-in hybrid car for local transportation. (i.e. trips less than 40-50 miles)



Update: Plug-in Hybrid (Chevy Volt)
Actuals 6/15/2012: Drove 788 miles.
Used electric generated by the Sun (free) and
0.7 gallons of gasoline (~1000 mpg)



- Plug-in Hybrid warranty: 100,000 miles / 8 years
 - Plug-in Hybrid replaces our Chrysler Town & Country Minivan @ 20 mpg for local travel
 - A Plug-in Hybrid driven ½ electric – ½ gasoline can save ~\$18,750 in gasoline cost over 100,000 miles (assumes average gas price is \$5 e.g. \$4 this year and \$6 in 10 years .)
- “... two years ago there were two plug-ins available, next year there will be a over a dozen.” Ref: plugincars.com, Aug 3, 2012.

Plug-in Hybrid Summary

Initial Cost (Tax, Registration)	\$43,569
Federal & State Tax Credits	\$13,500
Net Cost	\$30,069
Operation (Warranted)	8 years
	100,000 miles

Are Electric Vehicles Economical to Drive?

- Here's some data from www.fueleconomy.gov



- You make the call.
(We personally have verified the top three bars)

Summary / Conclusions

Our personal experiment illustrates one of many approaches to transition
FROM unsustainable “burning” of ancient hydrocarbons (coal, oil, gas)
TO sustainable “harvesting” of current sunlight
for residential energy needs and local transportation

- We no longer buy electrical power from Xcel Energy
- We no longer buy natural gas from Xcel Energy
- We no longer buy gasoline from Exxon Mobile or any other gasoline station
for our local travel

However, we are not yet living sustainably

- We still buy gasoline for cross-country trips,
 - So we are adding 14 more solar panels to generate an equivalent amount of energy consumed by burning this gasoline.
- We buy organic food grown locally through a Community Supported Agriculture (CSA) program
 - Although the food is produced organically without using fossil energy for pesticides, herbicides, or chemical fertilizer, it is not produced sustainably
 - Farm tractors, trucks, etc. are powered by burning fossil energy

BUT IT'S A START

(This transition from fossil fuel to Solar was completed in less than 1 year)

What's Next

More work to do in other renewable energy areas including:

- Sustainable Food Harvesting (plant & animal) / Food Preparation / Food Preservation
- Sustainable Material Resource Extraction / Accountability (Recycle every atom)
- Sustainable Manufacturing / Recycling (Cradle to Cradle)

Much more work to do in many other areas including:

- Sustainable Health Care
- Sustainable Education / Collective Learning (opportunity for all)
- Sustainable Government / Social Contracts
 - Sustainable Foreign Policy / Nonviolent Conflict Management
- Sustainable Corporations / Businesses
 - Sustainable Financial Investment / Wall Street
- Sustainable Growth
(Growth in Consciousness and Opportunity - NOT growth in global population , NOT growth in consumption)

- **Type of Construction**
 - Two-story wood frame built in 1974. 2000 Sq Ft
- **Construction Techniques- Thermal Envelope/Comfort**
 - Double or triple pane windows / sliding glass doors replaced all original windows / doors
 - Programmable Thermostat
 - Attic fan
- **Lighting**
 - CFL and LED Lighting
 - Solar powered yard lights
 - Skylight / Natural Lighting
- **Passive Features**
 - Passive Solar design sunroom
- **Active Features**
 - Electrical Power: Solar Electric PV, 5.6 kW, ~6800 kWh annual production - soon to be extended to 9.8 kW
 - Heating / Air Conditioning / Hot Water: GeoExchange/GeoThermal Heat Pump Furnace (No combustion / No carbon emissions)
 - Transportation: Plug-in Hybrid (Chevrolet Volt)
- **Appliances**
 - Energy Star rated: Dish Washer, Refrigerator
- **Water Features**
 - Drip Irrigation
- **Other Unique Features/Lifestyle**
 - Home is now powered, heated / cooled by solar energy (no burning of coal, oil or natural gas – no carbon emission)
 - Local transportation (40-50 mile trips) provided with plug-in hybrid operating on electric power provided by solar PV (no burning of gasoline – no carbon emission)
 - Net – Zero Energy (after 14 months of operation net-meter reading shows a 200 kWh credit)
 - Local vegetable produce via Community Supported Agriculture (CSA) with Grant Family Farms
 - 25' x 30' Terraced Organic Gardening area - no chemicals (weed killer, pesticides, herbicides) used on property (currently fallow)
 - Composting of all inedible vegetable matter
 - Outdoor compost pile
 - Indoor compost bin (NatureMill™)
 - Recycling (paper, plastic, metal, glass,...)
 - Canning and freezing seasonal foods

Postscript

Our transition to Solar power began as a personal experiment to simply explore ways to live more sustainably but resulted in a comprehensive switch from fossil energy to renewable energy for all our household needs. When combined with moderate conservation measures, the transition of our home to self-generated renewable energy was easy, so we decided to harvest additional sunlight for local transportation and purchased a plug-in hybrid vehicle.

We no longer buy electrical power (generated by burning coal), no longer buy natural gas (extracted from shale by hydraulic fracking), no longer buy gasoline for our local travel (trips less than 40-50 miles) thanks to the changes to our house.

For more information, check out our blog

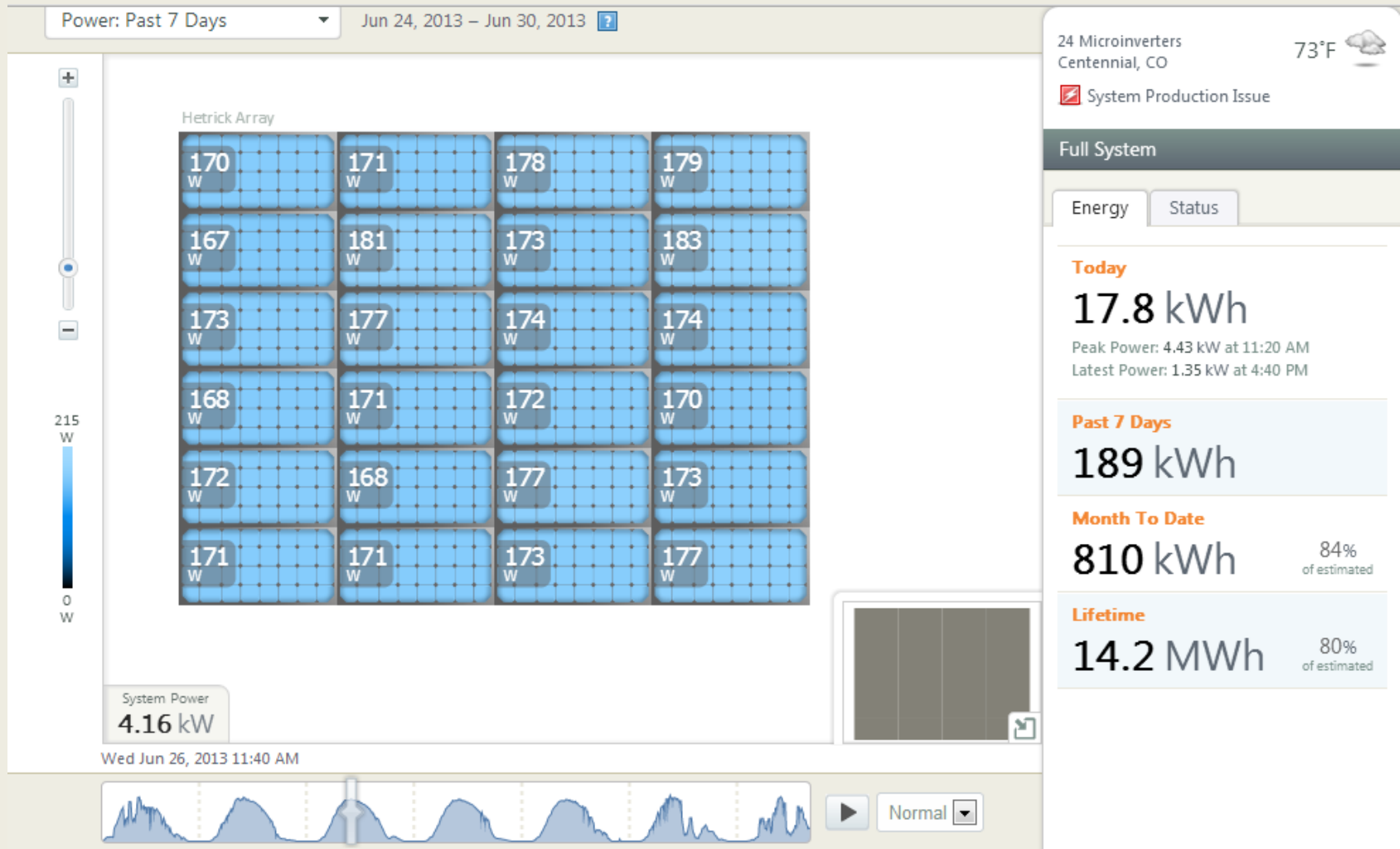
<http://www.nowforourturn.org/CosmicReflections/category/living-sustainably/>

System Performance Data

- The Solar PV system uses individual micro inverters on each module. The power from each module can be remotely monitored continuously using the internet: <http://enlighten.enphaseenergy.com> .
(An example is provided on the next slide)
- A usage monitoring system was added to the homes main electrical panel so that key circuits can be observed for power consumption.
(An example is provided on the last two slides.)

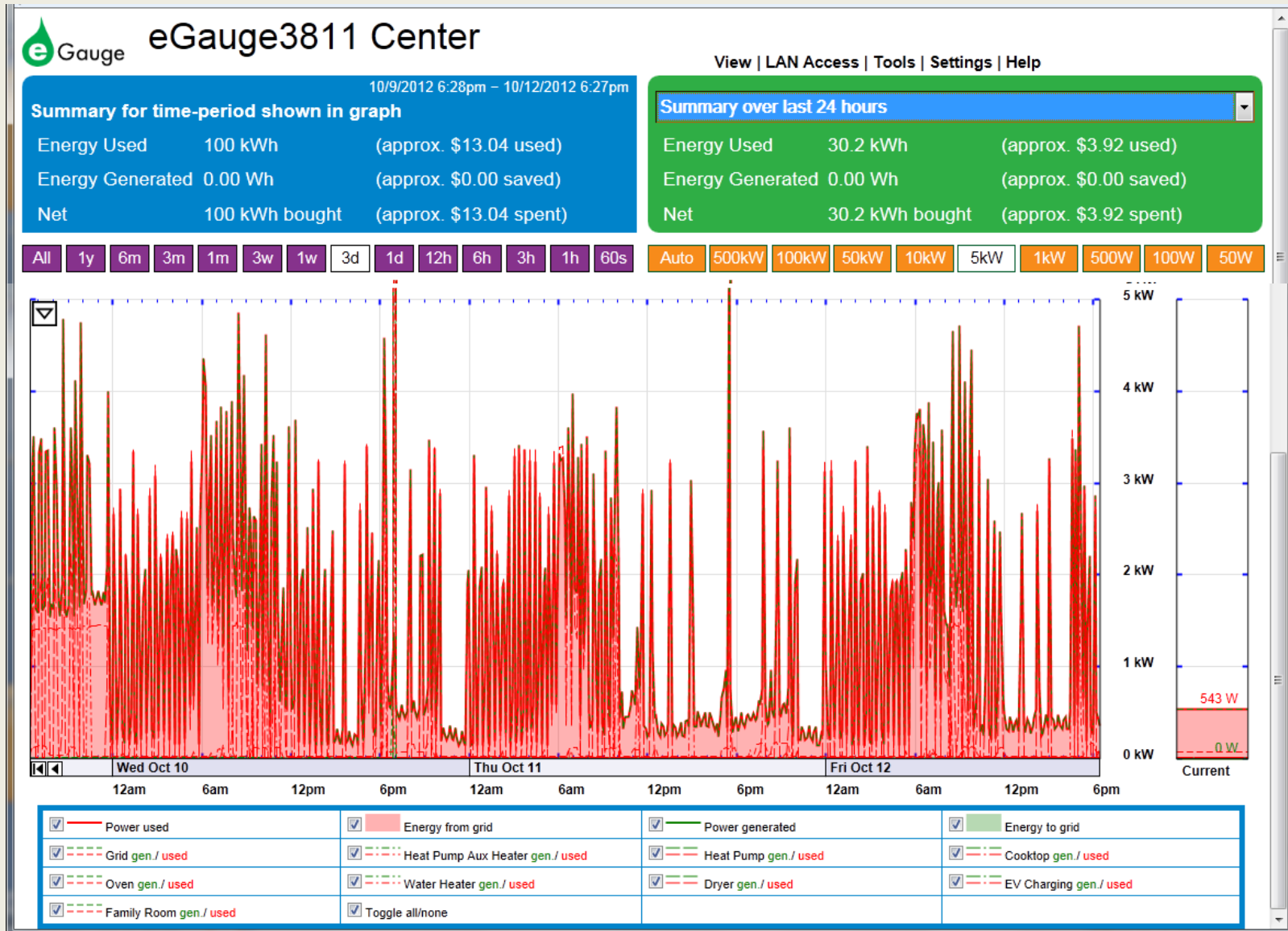
Enphase Solar Power Production Display

- Snapshot of power being produced at 11:40 am on June 26, 2013
(810 kWh was produced for the month of June with a retail price of \$97)



Energy Management System - eGauge

“You can’t manage something you don’t monitor” –engineering guideline



Energy Management System - eGuage

- Display showing two “appliances” - Water Heater & Geoexchange Heat Pump operation

