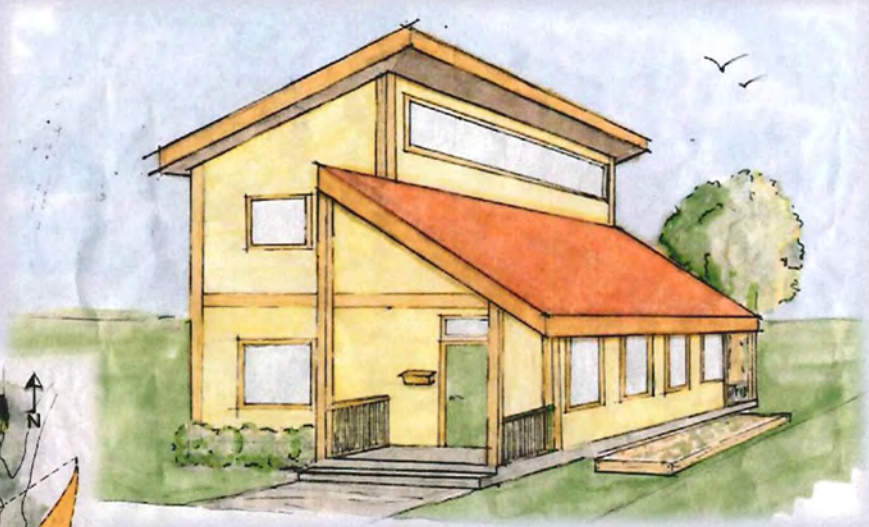


MOSAIC RIDGE PROJECT

Madison College – Introduction to Engineering Spring 2014

MADISON
AREA | TECHNICAL
COLLEGE

Table of Contents

Problem Statement	3
Heating Ventilation and Air Conditioning Design	4
Overview	5-6
Types of Systems	7-12
Cut Sheets and Submittals	13-16
Energy Recovery Ventilation	17-20
Water Heating	21-25
Greywater	26-29
Appliances & Lighting	30-36
Photovoltaic Systems	37-43
Energy Monitoring Systems	44-46
Budget	47-48
Company Resources	49-50
Sources of Information	51-55

Problem Statement

" A Mosaic of Green Strategies "

- Various programs at Madison College have been tasked to design and construct a net zero home; the Introduction to Engineering class has a responsibility to incorporate both the needs of the Mosaic Ridge Community and the vision of the Community Development Authority (CDA), by designing an energy system that utilizes both passive and active energy strategies. The design of the system shall reduce energy consumption and generate enough energy to offset the mechanicals in order to reach a net zero energy balance.

Addendum to Problem Statement (3/25/14)

- The Madison Community Development Authority (CDA) has teamed up with various programs at Madison College in a pilot project to design and construct an energy efficient home. The roughly 1300 square foot house is to be built in the Mosaic Ridge housing development. The resale value of the home should be approximately $200,000. It must comply with Madison's city building codes and design guidelines, and it must be capable of accommodating a single family. The primary objective of the engineering design class is to make the home energy efficient. The secondary objective is to design the home such that if the homebuyer wants to purchase a net-zero add-on, the home will be capable of producing as much energy as it consumes.

MC or Class Description

- Under the direction of:
  - Kenneth Walz – Instructor
  - Jon Christian – Instructor
  - Brian Gilbertson – Instructional Assistant

HVAC DESIGN

ADAM MASTALIR, CEDRIC M. PRICE

HVAC Definition

- HVAC stands for Heating Venting and Air Conditioning. It is based upon the principles of thermodynamics, fluid mechanics, and heat transfer. The main purpose behind HVAC systems is to condition the environment within a dwelling in order to achieve a a level of comfort for the occupants. There are a variety of ways in which this can be done and choosing the system which works best for your application is determined by the results in which you are trying to achieve. According to the United States Department of Energy (DOE) HVAC systems account for over 40% of the energy consumed by a typical household in America.

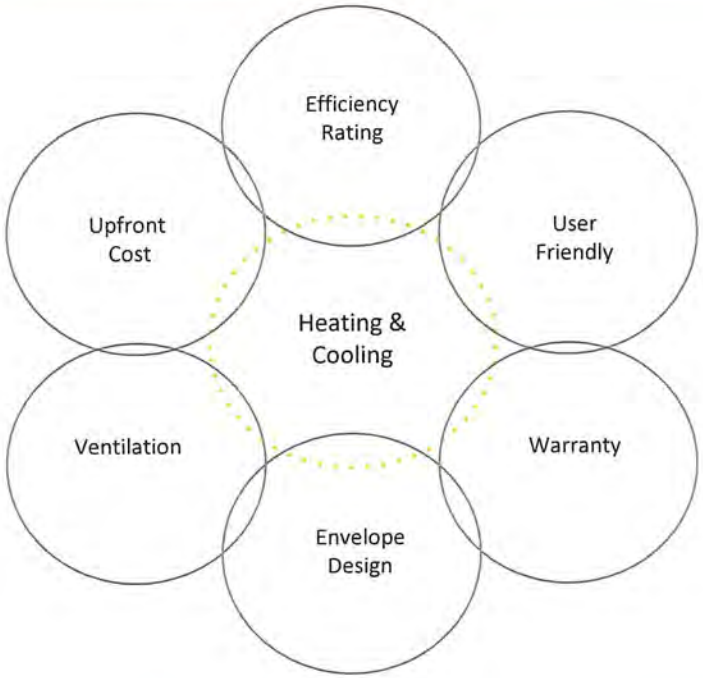
HVAC Problem Statement

- We have been tasked to research and design a system which is capable of conditioning the environment of the dwelling in a way that helps us to reduce our energy consumption. The system shall be capable of offsetting any heat loss or gain that is introduced through a shift in the balance between indoor and outdoor temperatures. It is our responsibility to narrow the available options and recommend a system to our client that achieves this, all the while maintaining energy efficiency.

Project Overview

- When choosing a system to condition our environment, it is important to determine the amount of heat that will be transferred from our system to the surroundings, as well the climate of the surroundings in which heat will be transferred to or from. The design temperatures will be based on seasonal data and used with our heat loss calculations to help compare costs and efficiencies of fuels. In correlation with initial feedback we received from our client as well as the architectural and construction teams, we compiled a list of general guidelines to help us determine our design considerations. Our professional recommendation of a system is based upon the compiled research and how well we feel it will fit into the overall design.

Design Considerations



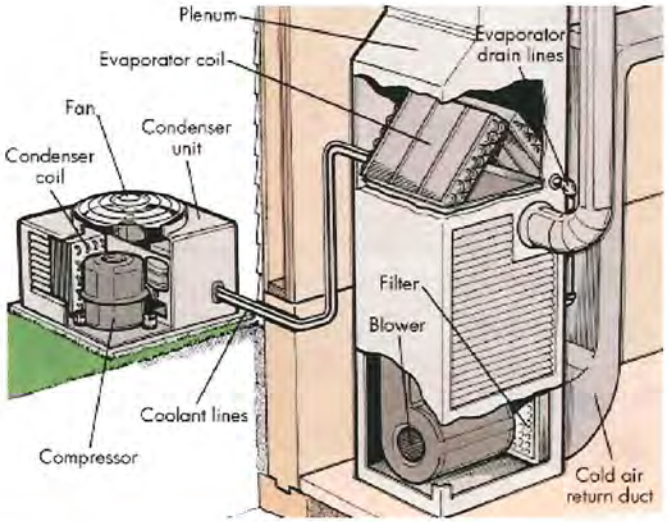
Compiled List of Systems

- Gas Furnace
- Air Source Heat Pumps
- Ground Source Heat Pumps
- Condensing Boiler
- Photo Voltaic
- Electric Baseboard

General Guidelines

- Heat Loss/Gain Calculations
  - Square Feet × U Rating × Δ T = Total Heat Loss
  - Indoor Design Temps are set to (70° / 75°F)
  - Outdoor Design Temps are set to (-16.6° / 94.6°F)
    - Outdoor Design Temperatures are based on the ASHRAE 99% Dry bulb temperature for February and the 1% Dry Bulb temperature for July.
- Fuel Consumption Calculations
  - (Total Heat Loss × Degree Days × 24) ÷ (Efficiency × ΔT × BTU Factor)
    - Kilo Watt Hours are based on the mean degree-days for Madison, WI. Data provided by the University of Tennessee, Knoxville
- Architectural and Construction Considerations
  - Duct Free Air Distribution
  - Limited Attic Head Space
  - Minimal Technology
- Additional Considerations
  - Cost and lifespan of system
  - Operation and maintenance of system
  - Additional components to system

System Diagram



Delivery Method Diagram

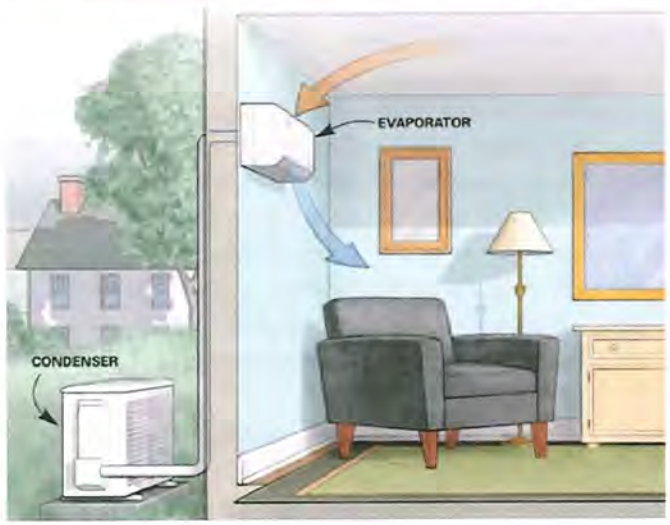
	Unit	Estimate Need	Cost Estimate
Heating			
R-6 Ductwork	Per linear foot	150	$ 4.00
Furnace	Per Unit	Single	$ 800.00
A/C	Per Unit	Single	$ 900.00
Materials	N/A	N/A	$ 300.00
Labor	Per hour	10 - 15	$ 50.00

(1) Estimates gathered from homewyse.com

Overview

- Due to their ability to distribute conditioned air for both heating and cooling to various locations throughout the dwelling, this ducted system is one of the more common systems being installed in newer homes today. With lowered costs and increased efficiencies, the only major draw back is the uncertainty of future gas prices. Although conversions to offset gas consumption are possible, they can not be directly offset through an equal conversion if a PV system were installed. Two other drawbacks to this system are the initial required duct work, and heating comfort level. Due to the forced air system, the heat is distributed unevenly once it leaves the vent.
- Over time the system can also accumulate a variety of Indoor Air Quality (IAQ) Issues if it is not properly maintained.
- One of the biggest advantages to these systems is that there is wide range of manufactures so the market is competitive. Additionally, many repair companies specialize in specific brands of systems so there is comfort in knowing that a professional should be easily accessible for service and repairs.

System Diagram



System Costs

	Unit	Estimate Need	Cost Estimate
Heating			
System	Per Unit	Single	$ 2000.00
Materials	N/A	N/A	$ 75.00
Labor	Per Hour	5 - 8	$ 50.00

(1) Estimates gathered from homewyse.com

Overview

- Air source heat pumps have the ability to both heat and cool a home through the use of a single system. The heat pump itself transfers heat through the use of a refrigerant. A compressor converts the refrigerant from a liquid to a gas, or vice versa. Depending on the time of year, the refrigerant will either extract or release heat from one environment to another. No air is actually exchanged and no fossil fuels are burned in this process.
- This type of system allows us many different options as well as flexibility when it comes to installation. Mini Split systems allow for duct free heating and cooling while simultaneously maintaining some of the highest levels of efficiency.
- The one drawback to this system is that it would require us to install a supplemental heat source in each bedroom to help reduce the cost of installation and maintain building code requirements.
- Mini split systems are the best, most viable option currently available. With correct sizing, a mini split will be capable of heating and cooling the home efficiently. Moreover, a correctly sized mini split system will minimize short cycling, effectively lengthening its life expectancy.

Geothermal System Functions:

- Geothermal harnesses the earth's consistent temperatures to offset energy bills.
- A pump moves environmentally friendly fluids through pipes and into the house. A refrigerant cycle captures the heat/cold and disburses it with a forced air system.

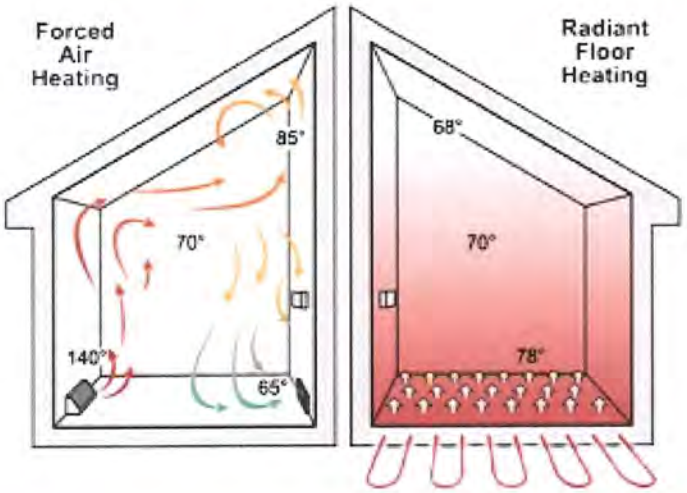
Installation process:

- After drilling, the pipes must be secured into the ground. This is done with a grout that when dries is soft and pliable.
- Texture is consistent with wet cat litter.
    - Cannot plant over it.
    - Unsightly.

Vital components:

- The most expensive part of geothermal is the heat pump.
    - The cost of installed equipment has risen 177% over the last 19 years, while the pipes and labor have only risen 55%.
    - Geothermal still requires ducts and a forced air system to move heat around.
        - Forced air requires electricity.
- Aftercare:
    - An unintended consequence of geothermal is aftercare.
    - The system itself will last a long time, but the drilling process can make a huge mess!
    - This can result in expensive lawn renovations and clean up.

System Diagram



System Costs

	Unit	Estimate Need	Cost Estimate
Heating			
System	Per Unit	Single	$ 3000.00
Materials	N/A	N/A	$ 225.00
Labor	Per hour	10 -14	$ 50.00

(1) Estimates gathered from homewyse.com

Overview

- The use of a high efficiency low condensing boiler to heat your home is achieved through hydronic radiant heating. A series of pipes are distributed through the flooring system which carry hot water from the boiler. One of the main benefits of a system like this is that it allows you to heat your home in zones. It also allows you to couple the system with your water heater allowing for a multipurpose setup. Doing so also increases the efficiency of a gas water heater due to the lack of flash points on the bottom of the storage tank.
- The biggest draw back is that this system does not include a form of cooling for the warmer seasons.
- We would only recommend this system if whole house radiant floor heating was required and if the home were to be constructed on site. This is because of the way in which these systems are installed. Furthermore, the materials used to increase the effectiveness of heat transfer and storage would add weight to the structure, potentially increasing the cost of transportation between the builder and the construction site.

Cost Comparison

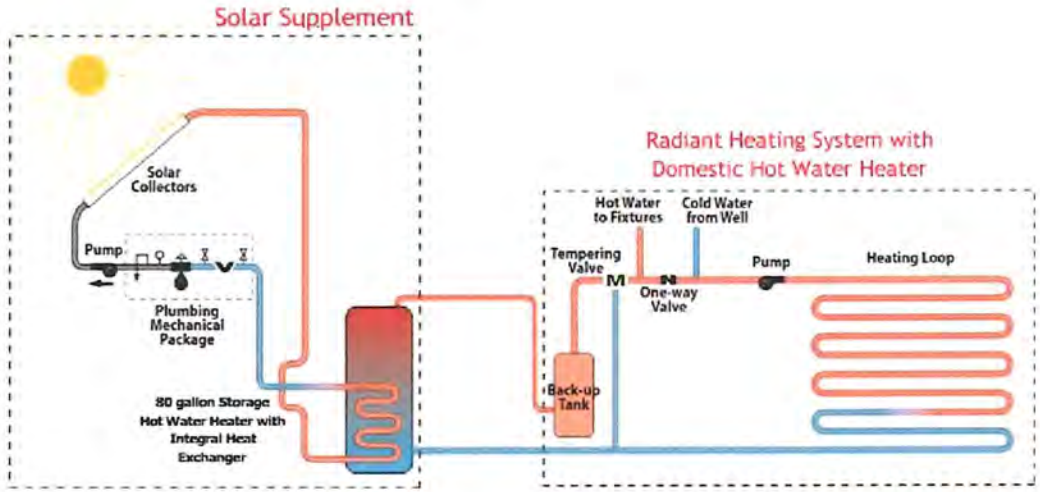
- Solar Collector and Storage Tank
  - - $10,000.00
- 1.7 watt PV Array and Heat Pump Water Heater
  - -$10,000.00
  - Produce 2,093 kWh per year or 64 gallons of Hot water per day

Green Building Advisor – David Holladay

Overview

- Photovoltaic heating is achieved through an in floor radiant system. The graph included below shows how heat is captured from the sun in a solar collector. The solar collector then circulates a liquid through a loop, which transfers this heat to a storage tank similar to a water heater. Finally, the water in the tank is distributed to various areas within the system to release the heat before returning back to the storage tank to start the process over again.
- The are many benefits and drawbacks to a system like this. In mild climates, it is feasible to say that you could couple a system like this with your hot water heating system in order to achieve a low cost alternative to heating your home. However, in a Wisconsin climate, there are few examples of systems like these, and they are being used as nothing more than a form of supplemental heating. Also, due to the decreasing cost in PV Panels and Heat Pump Water Heaters, Solar Collectors are being slowly eliminated as a system.

Diagram



System Diagram

Overview

- The most common form of electrical heating is achieved through conduction. This method of heating draws cool air up from the ground and across coils and then out into the room affecting the dry bulb temperature. This form of heating serves best when supplemental zone heating is desired.
- A secondary form of electrical heating is achieved through radiance. This method of heating is similar to the way in which our sun heats our planet. Instead of affecting the dry bulb temperature by heating the air, radiant heaters directly heat the objects within the room.
- The two systems are represented in the diagrams to the left. Radiant directs heat at objects while conduction heats the entire room.
- Overall electrical systems are beneficial when concerned about Indoor Air Quality (IAQ) as they introduce no pollutants to the air and burn no fuels to operate. They rarely suffer from mechanical failure due to the lack of moving parts. One of the main reasons we have considered electrical heating as a supplemental heating source is due in part to their low costs and easy installation.

System Costs

	Unit	Estimate Need	Cost Estimate
Heating			
Infrared Panel	Per Unit	3	$ 335.00
Materials	N/A	N/A	$ 125.00
Labor	Per hour	4 - 6	$ 50.00

(1) Estimates gathered from homewyse.com

Based on Design with Increased R-Values

Apricity House Heat Loss/Gain

Engineer: Adam Mastalir
Date: 4/1/14

Design Temperatures (Max-Min)
Indoor 70 75
Outdoor (DB) -16.6 94.64

Room	Portion Considered	Exterior Wall Dimensions (inches)	Height (inches)	Square Footage	Openings	Opening Area	Net Opening Area	U Value	Winter ΔT	Summer ΔT	Heat loss (Btuh)	Total heat loss (Btuh)	Heat Gain (Btuh)	Total heat gain (Btuh)	Room heat loss (Btuh)	Room heat gain (Btuh)
Bed 1	Wall - N	154.50	96.00	103.00				0.01667	86.60	19.64	140.97	210.25	31.97	47.68	640.74	131.48
	Wall - W	192.00	96.00	128.00				0.01667	86.60	19.64	161.65	369.49	36.66	83.80		
	Window - N				1.00	5.33	5.33	0.15000	86.60	19.64	69.28		15.71			
	Window - W				1.00	16.00	16.00	0.15000	86.60	19.64	207.84		47.14			
	Floor			183.00				0.03333	10.00		61.00	61.00				
Bed 2	Wall - N_{approx}	154.50	97.00	104.07				0.01667	86.60	19.64	142.51	211.79	32.32	48.03	587.71	133.29
	Wall - W_{approx}			164.45				0.01667	86.60	19.64	220.03	375.91	49.90	85.25		
	Window - N				1.00	5.33	5.33	0.15000	86.60	19.64	69.28		15.71			
	Window - W				1.00	12.00	12.00	0.15000	86.60	19.64	155.88		35.35			
	Floor			116.00				0.03333	2.00	2.00	7.73	7.73	7.73	7.73		
Bed 3	Wall - N_{approx}	144.00	97.00	97.00				0.01667	86.60	19.64	132.31	201.59	30.01	45.72	489.27	110.96
	Wall - E_{approx}			167.32				0.01667	86.60	19.64	235.73	287.69	53.46	65.24		
	Window - N				1.00	5.33	5.33	0.15000	86.60	19.64	69.28		15.71			
	Window - E				1.00	4.00	4.00	0.15000	86.60	19.64	51.96		11.78			
	Floor			161.00				0.03333	2.00	2.00	10.73	10.73	10.73	10.73		
Bath 1	Wall - N	60.00	96.00	40.00				0.01667	86.60	19.64	57.73	57.73	13.09	13.09	65.40	13.09
	Floor			46.00				0.03333	5.00		7.67	7.67				
Bath 2	Wall - N_{approx}	60.00	97.00	40.42				0.01667	86.60	19.64	58.33	58.33	13.23	13.23	58.33	13.23
	Floor			46.00				0.03333	2.00	2.00	3.07	3.07	3.07	3.07		
Mudroom	Wall - N	127.50	96.00	85.00				0.01667	86.60	19.64	92.37	213.61	20.95	48.45	213.61	48.45
	Door - N				1.00	21.00	21.00	0.06667	86.60	19.64	121.24		27.50			
	Floor			123.00				0.03333	10.00		41.00	41.00				
Kitchen	Wall - N	144.00	96.00	96.00				0.01667	86.60	19.64	138.56	138.56	31.42	31.42	1,348.33	290.74
	Wall - E	225.00	96.00	150.00				0.01667	86.60	19.64	161.97	1,143.44	36.73	259.32		
	Door - E				1.00	37.78	37.78	0.30000	86.60	19.64	981.47		222.59			
	Floor			199.00				0.03333	10.00		66.33	66.33				
Dining	Wall - E	15,781.52	Included	109.59				0.01667	86.60	19.64	158.18	158.18	35.87	35.87	186.18	35.87
	Floor			84.00				0.03333	10.00		28.00	28.00				
Living	Wall - S	527.00	140.14	512.87				0.01667	86.60	19.64	717.15	924.99	162.64	209.78	1,057.32	209.78
	Window - $S_{(x4)}$				4.00	4.00	16.00	0.15000	86.60	19.64	207.84		47.14			
	Floor			397.00				0.03333	10.00		132.33	132.33				
Entry	Wall - W	15,781.52	Included	115.35				0.01667	86.60	19.64	136.18	257.42	30.88	58.38	257.42	58.38
	Door - W				1.00	21.00	21.00	0.06667	86.60	19.64	121.24		27.50			
Balcony	Wall - N_{approx}	127.50	97.00	85.89				0.01667	86.60	19.64	123.96	123.96	28.11	28.11	123.96	28.11
	Floor	2,664.00		222.00				0.03333	1.00	2.00	7.40	7.40	14.80	14.80		
Vault Area	Wall - S	527.00	56.40	206.42				0.01667	86.60	19.64	237.31	519.24	67.57	315.03	519.24	315.03
	Window - $S_{(x7)}$				7.00	6.00	42.00	0.30000	86.60	19.64	1,091.16		247.46			
Foundation	Wall - N	515.00	96.00	343.33	343.33			0.01667	86.60		495.54	495.54			2,227.84	
	Wall - E	293.00	96.00	195.33				0.01667	86.60		281.93	281.93				
	Wall - S	515.00	96.00	343.33				0.01667	86.60		495.54	495.54				
	Wall - W	293.00	96.00	195.33				0.01667	86.60		281.93	281.93				
	Floor			1,009.33				0.03333	20.00		672.89	672.89				
Roof	South			691.00				0.01111	20.00	45.00	153.56	153.56	345.50	345.50	325.33	732.00
	North			773.00				0.01111	20.00	45.00	171.78	171.78	386.50	386.50		
Totals	Condition Spaces			1,577.00											5,872.86	2,120.42

Based on Design with Standard R-Values

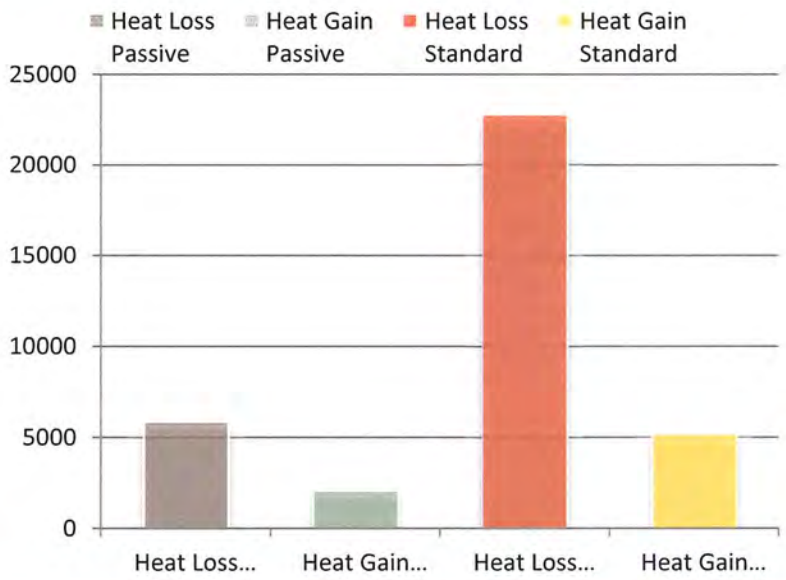
Apricity House Heat Loss/Gain

Engineer: Adam Mastalir
Date: 4/1/14

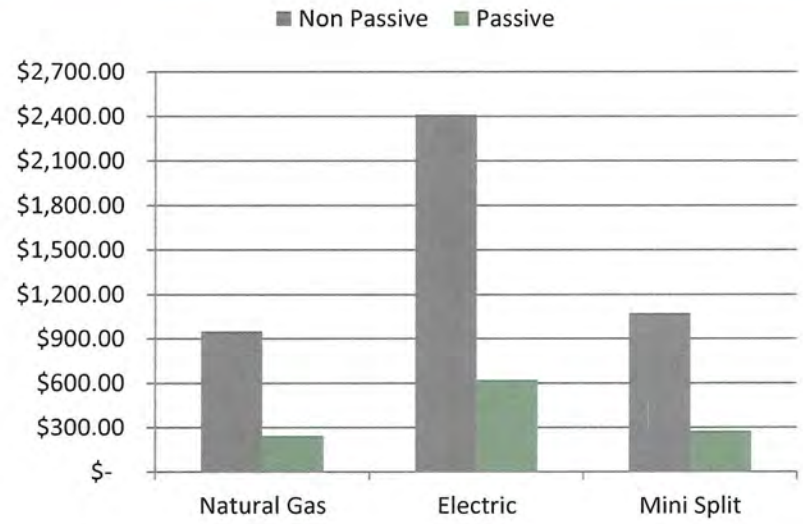
Design Temperatures (Max-Min)
Indoor 70 75
Outdoor (DB) -15.6 94.64

Room	Portion Considered	Exterior Wall Dimensions (inches)	Height (inches)	Square Footage	Openings	Opening Area	Net Opening Area	U Value	Winter ΔT	Summer ΔT	Heat loss (Btuh)	Total heat loss (Btuh)	Heat Gain (Btuh)	Total heat gain (Btuh)	Room heat loss (Btuh)	Room heat gain (Btuh)
Bed 1	Wall - N	154.50	96.00	103.00	-	-	-	0.05263	86.60	19.64	445.15	583.71	100.96	132.38	3,339.88	342.43
	Wall - W	192.00	96.00	128.00	-	-	-	0.05263	86.60	19.64	510.48	926.16	115.77	210.04		-
	Window - N	-	-	-	1.00	5.33	5.33	0.30000	86.60	19.64	138.56	-	31.42	-		-
	Window - W	-	-	-	1.00	16.00	16.00	0.30000	86.60	19.64	415.68	-	94.27	-		-
	Floor	-	-	183.00	-	-	-	1.00000	10.00	-	1,830.00	1,830.00	-	-		-
Bed 2	Wall - N approx	154.50	97.00	104.07	-	-	-	0.05263	86.60	19.64	450.04	588.60	102.07	133.49	1,595.20	361.78
	Wall - W approx	-	-	164.45	-	-	-	0.05263	86.60	19.64	694.84	1,006.60	157.58	228.29		-
	Window - N	-	-	-	1.00	5.33	5.33	0.30000	86.60	19.64	138.56	-	31.42	-		-
	Window - W	-	-	-	1.00	12.00	12.00	0.30000	86.60	19.64	311.76	-	70.70	-		-
	Floor	-	-	116.00	-	-	-	1.00000	2.00	2.00	232.00	232.00	232.00	232.00		-
Bed 3	Wall - N approx	144.00	97.00	97.00	-	-	-	0.05263	86.60	19.64	417.81	556.37	94.75	126.18	1,404.69	318.57
	Wall - E approx	-	-	167.32	-	-	-	0.05263	86.60	19.64	744.41	848.33	168.82	192.39		-
	Window - N	-	-	-	1.00	5.33	5.33	0.30000	86.60	19.64	138.56	-	31.42	-		-
	Window - E	-	-	-	1.00	4.00	4.00	0.30000	86.60	19.64	103.92	-	23.57	-		-
	Floor	-	-	161.00	-	-	-	1.00000	2.00	2.00	322.00	322.00	322.00	322.00		-
Bath 1	Wall - N	60.00	96.00	40.00	-	-	-	0.05263	86.60	19.64	182.32	182.32	41.35	41.35	412.32	41.35
	Floor	-	-	46.00	-	-	-	1.00000	5.00	-	230.00	230.00	-	-		-
Bath 2	Wall - N approx	60.00	97.00	40.42	-	-	-	0.05263	86.60	19.64	184.21	184.21	41.78	41.78	184.21	41.78
	Floor	-	-	46.00	-	-	-	1.00000	2.00	2.00	92.00	92.00	92.00	92.00		-
Mudroom	Wall - N	127.50	96.00	85.00	-	-	-	0.05263	86.60	19.64	291.71	412.95	66.16	93.65	412.95	93.65
	Door - N	-	-	-	1.00	21.00	21.00	0.06667	86.60	19.64	121.24	-	27.50	-		-
	Floor	-	-	123.00	-	-	-	1.00000	10.00	-	1,230.00	1,230.00	-	-		-
Kitchen	Wall - N	144.00	96.00	96.00	-	-	-	0.05263	86.60	19.64	437.56	437.56	99.23	99.23	3,920.52	437.82
	Wall - E	225.00	96.00	150.00	-	-	-	0.05263	86.60	19.64	511.50	1,492.96	116.00	338.59		-
	Door - E	-	-	-	1.00	37.78	37.78	0.30000	86.60	19.64	981.47	-	222.59	-		-
	Floor	-	-	199.00	-	-	-	1.00000	10.00	-	1,990.00	1,990.00	-	-		-
Dining	Wall - E	15,781.52	Included	109.59	-	-	-	0.05263	86.60	19.64	499.52	499.52	113.29	113.29	1,339.52	113.29
	Floor	-	-	84.00	-	-	-	1.00000	10.00	-	840.00	840.00	-	-		-
Living	Wall - S	527.00	140.14	512.87	-	-	-	0.05263	86.60	19.64	2,264.67	2,680.35	513.60	607.88	6,650.35	607.88
	Window - S (x4)	-	-	-	4.00	4.00	16.00	0.30000	86.60	19.64	415.68	-	94.27	-		-
	Floor	-	-	397.00	-	-	-	1.00000	10.00	-	3,970.00	3,970.00	-	-		-
Entry	Wall - W	15,781.52	Included	115.35	-	-	-	0.05263	86.60	19.64	430.05	551.29	97.53	125.03	551.29	125.03
	Door - W	-	-	-	1.00	21.00	21.00	0.06667	86.60	19.64	121.24	-	27.50	-		-
Balcony	Wall - N approx	127.50	97.00	85.89	-	-	-	0.05263	86.60	19.64	391.46	391.46	88.78	88.78	391.46	88.78
	Floor	2,664.00	-	222.00	-	-	-	1.00000	1.00	2.00	222.00	222.00	444.00	444.00		-
Vault Area	Wall - S	527.00	56.40	206.42	-	-	-	0.05263	86.60	19.64	749.39	1,639.70	213.37	460.83	1,639.70	460.83
	Window - S (x7)	-	-	-	7.00	6.00	42.00	0.30000	86.60	19.64	1,091.16	-	247.46	-		-
Foundation	Wall - N	515.00	96.00	343.33	343.33	-	-	0.05263	86.60	-	1,564.88	1,564.88	-	-	6,592.59	-
	Wall - E	293.00	96.00	195.33	-	-	-	0.05263	86.60	-	890.31	890.31	-	-		-
	Wall - S	515.00	96.00	343.33	-	-	-	0.05263	86.60	-	1,564.88	1,564.88	-	-		-
	Wall - W	293.00	96.00	195.33	-	-	-	0.05263	86.60	-	890.31	890.31	-	-		-
	Floor	-	-	1,009.33	-	-	-	0.08333	20.00	-	1,682.22	1,682.22	-	-		-
Roof	South	-	-	691.00	-	-	-	0.03333	20.00	45.00	460.67	460.67	1,036.50	1,036.50	976.00	2,196.00
	North	-	-	773.00	-	-	-	0.03333	20.00	45.00	515.33	515.33	1,159.50	1,159.50		-
Totals	Condition Spaces														22,818.09	5,229.17

Heat Loss and Heat Gains



Annual Fuel Cost Consumption y System



Heat and Fuel Report

	Square Footage	Heat Loss (BTU/hr)	Heat Gain (BTU/hr)
Passive			
Foundation	2087	2227	0
1st Floor	2371	3769	788
2nd Floor	1188	1779	600
Roof	1464	325	732
Total	7110	8100	2120
Non Passive			
Foundation	2087	6593	0
1st Floor	2371	16627	1762
2nd Floor	1188	5215	1230
Roof	1464	976	2196
Total	7110	29411	5188

Fuel Costs

	Natural Gas	Electric	Mini Split
Non Passive (R19)	$952.40	$2410.99	$1071.87
Passive (R60)	$245.13	$620.55	$275.80
Net savings	$707.27	$1790.44	$796.07

(1) Electrical Fuel costs were based on an estimated value of $0.12 per kWh
(2) Natural Gas Fuel costs were based on an estimated value of $1.25 per therm.
(3) Total heat loss and gains include the foundation where as chart does not include this as a conditioned space

Heating Systems and Thermostats

Equipment (Main)	Model	SEER Rating	Operation Range (degrees Fahrenheit)	BTU	Warranty (Compressor / Parts)	Cost
Mitsubishi	MSZFE09NA8 / MUZFE09NAB	26	-15	9000 / 10900	7 year / 5 year	$2375.00
LG	LS091HSV3	21.5	-5	9000 / 10800	5 year / 3 year	$1744.00
Fujitsu	ASU9RLS2 / AOU9RLS2	27	-5	9000 / 12000	7 year / 5 year	$1600.00

Equipment (Supplemental)	Model	Type	Mounting	Volts / Watts	Warranty	Cost
REH	632C	Infrared Radiant	Cove	120 / 585	10 year	$335.00
Comfort Cove	C4512	Convection Radiant	Cove	120 / 450	10 year	$81.00
Cadet	2F5001W	Convection Radiant	Baseboard	120 / 500	N/A	$31.00

Thermostat Brand	Model	Type	Filter Reminder	Mobile Control	Programmable	Cost
Nest	2nd Generation	Heat Pump	Yes	Yes	7-Day Smart	$249.00
Mitsubishi	MHK1	Heat Pump	Yes	Yes	7-Day	$243.00
Honeywell	TL8230	Electric	N/A	N/A	7-Day	$53.71

HVAC System Recommendations

- After calculating the heat loss and heat gains through the structure of the building, we determined that the main heating system could be easily oversized. To help avoid short cycling and unnecessary wear and tear on the components, a Mini Split Heat Pump system was chosen. Mini Split systems are a common source of household heating and cooling in Passive House designs and their life expectancy is 15 years. Parts and service of these systems are readily available in the area. The heat pump was sized to control the wet and dry bulb temperatures during maximum cooling and heating performance.
- As a supplemental heating option, radiant electric heat is recommended in each bedroom of the dwelling that can be isolated by a door from the main living area. Each radiant panel in the dwelling shall be controlled with an independent programmable thermostat.

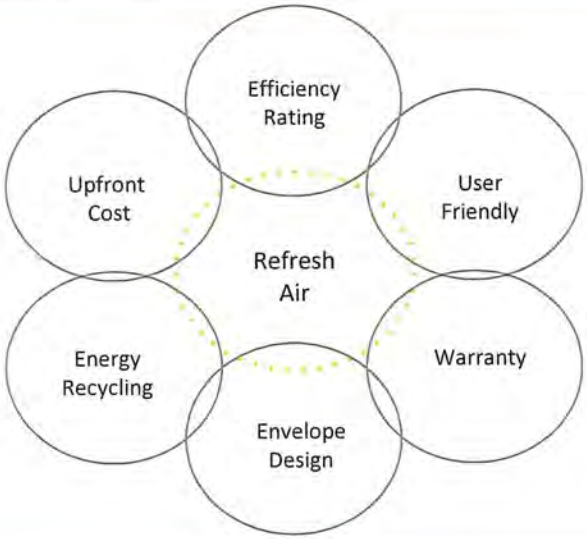
Thermostat Recommendation

- Install a minimum seven-day programmable Energy Star thermostat on the main heating component that has the ability to operate a heat pump system. The thermostat shall have the ability to accommodate daily schedules and be flexible for a variety of possible homeowners. It should provide maximum efficiencies of equipment and assist the homeowner with controlling heating and cooling costs when possible. A separate, programmable thermostat shall control all supplemental heating. This will allow for zoned heating in the isolated areas of the dwelling.

ENERGY RECOVERY VENTILATOR (ERV)

JUSTIN YARRINGTON, KAZU MURAKAMI

Design Considerations



ERV Considerations

- The ERV unit installed must be capable of refreshing the air in a household of approximately 1300 sq. ft. while also keeping the air quality comfortable for the residents. The ERV unit will also lower the cost of the installed HVAC system by recovering and reusing energy from both the air within the household and the air brought in from outside. Furthermore, an ERV will reduce the energy requirement by the HVAC system to heat and cool the household air.

General Guidelines

- Requires ductwork
    - HVAC installer will have to make sure to install appropriate duct work to all 3 bathrooms as well as a vent near the kitchen.
- User friendly interface
    - Peripherals allow the occupants to adjust the airflow according to their own preference and comfort levels
- CFM (cubic feet per minute) of airflow will be determined by rooms, bathrooms, and house occupants.
    - Airflow should meet the requirement for the number of people residing in the household, 15 CFM per person.
    - Airflow should also meet the recommendation for the appropriate number of bathrooms in the house, an additional 15 CFM per bathroom.
    - The system should have at minimum 150 CFM for the house layout, suitable for 4 occupants to be comfortable.
- Maintenance should be user friendly
    - Occupants should easily be able to maintain the system
    - System should preferably not require routine maintenance at occupants' expense.

ERV Systems

Model	CFM	Warranty (core/parts)	Dimensions	Cost
Renewaire EV200	100-210	10 year/2 year	28.75"x20.125"x 24"	$580

Model	CFM	Warranty (core/parts)		Cost
Venmar Constructo 1.2	130	5 year/5 year	35"x30.25"x 17.125"	$1500

Model	CFM	Warranty (core/parts)		Cost
Zehnder ComfoAir 350	218	2 year/2 year	27.6"x30"x22.5"	$2200

Our Recommendation

- The RenewAire EV200 meets all of the specifications and desires for an ERV system for a 1300 sq.ft. household. The EV200 also has the highest rated performance and efficiency compared to competing ERV systems. While also providing the best performance, RenewAire has offered to provide us a unit for reduced cost while also offering the peripherals (user interface) for no charge.

RenewAire®
Energy Recovery Ventilation
The Natural Choice for Fresher Air

EV200 Spec Details

EV200 - Energy Performance								
Supply Temperature		Net Airflow		Supply/Exhaust Flow Ratio	Average Power Watts	Sensible Recovery Efficiency	Apparent Sensible Effectiveness	Net Moisture Transfer
C°	F°	L/S	CFM					
Heating								
0°	32°	30	64	0.96	100	79	93	0.73
0°	32°	46	97	0.98	112	75	85	0.68
0°	32°	61	128	0.98	127	77	84	0.63
-25°*	-13°	30	64	0.93	105	52	78	0.56
Cooling						Total Recovery Efficiency		
35°	95°	30	63	0.99	97	59		

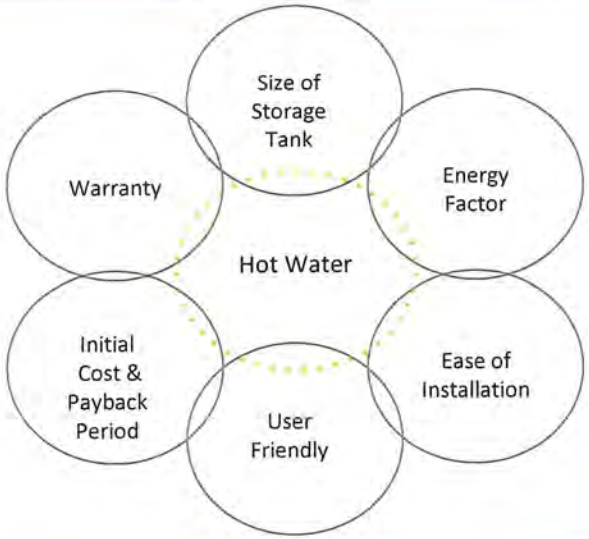
- The EV200 unit offers very high efficiency ratings when heating compared to competing models, while also maintaining one of the highest efficiencies when cooling as well. It is important to note that efficiency is much lower when cooling because the change in temperature from outside to inside is often very small when compared to heating from 32 F to room temperature. The EV200 is also sufficiently at extracts moisture from the air, making it an ideal choice in replacing the bathroom venting. The EV200 unit is also reliable because of the long warranty on the core. Lastly, purchasing the EV200 from a company located within the Madison area offers that company a chance to promote its products.

EV200 - Ventilation Performance							
Ext. Static Pressure		Net Supply Airflow		Gross Airflow			
				Supply		Exhaust	
Pa	in. wg	L/S	CFM	L/S	CFM	L/S	CFM
25	0.1	91	193	94	199	98	208
50	0.2	90	192	93	198	97	205
100	0.4	84	178	87	184	95	200
150	0.6	78	165	80	170	85	180
200	0.8	61	129	63	134	62	132
225	0.9	11	23	11	24	23	48

WATER HEATING

PEDAR HAYES, KEN ZANDER, ERIC BENSON

Design Considerations



Hot Water Description

- A water heater is an essential part of a home. It provides the residents with hot water so they can cleanse themselves, their dishes, their laundry, etc. It was decided that a water heater with a storage tank will best suit the high hot water demands throughout the day whilst also minimizing energy consumption and maximizing efficiency. Other types of water heaters considered were tankless and solar (see General in next slide).

General Guidelines

- A residential dwelling consumes 16 gallons of hot water per person per day: 4 persons x 16 gallons = 64 gallons per day
    - The 64 gallons per day calculation is valuable in helping size the hot water storage tank.
    - The size of the storage tank is dependent upon hot water usage during the peak demand as well as standby heat losses
    - Peak demand is defined as the busiest hot water usage period in a day
    - Standby heat losses are defined as the heat the water will lose over time while it is sitting in the storage tank
    - A 50 gallon holding tank will best suit the needs of this home. It will keep up with the peak demand period and it will minimize standby losses
- The energy factor is a ratio of how much energy is put into the water divided by how much energy is used to heat the water. A high energy factor (EF) is preferable.
- Since the Madison College construction program will be installing the water heater, it was decided that the installation should be relatively unsophisticated
- The water heater should also be low maintenance and user friendly for the homeowner
- It is recommended that the water heater be selected such that the warranty lasts substantially longer than the payback period. This will guarantee that the water heater pays for itself before it costs money to be repaired or replaced
- A longer warranty implies that the product is more durable and will have a longer lifespan in general
- Since the home will be solar ready, the water heater should be capable of being powered by a photovoltaic (PV) system

Water Heating Options

Brand	Model	Gas/Electric	Energy Factor	Energy Usage (kWh/Year)	First Hour Delivery	Warranty	Cost (Initial/Annual)	Payback Period
GE GeoSpring Hybrid	**GeoSpring Hybrid**	**Electric**	**2.45**	**1,583**	**65 Gallons**	**10 year**	**$1100/$220**	**3 years**
A.O. Smith	PCRT – 52	Electric	0.93	4,400	62 Gallons	10 Year	$650/$503	7.5 years
A.O. Smith	GAHH – 50	Gas	0.70	10,000	81 Gallons	6 Year	$800/$261	2.5 years

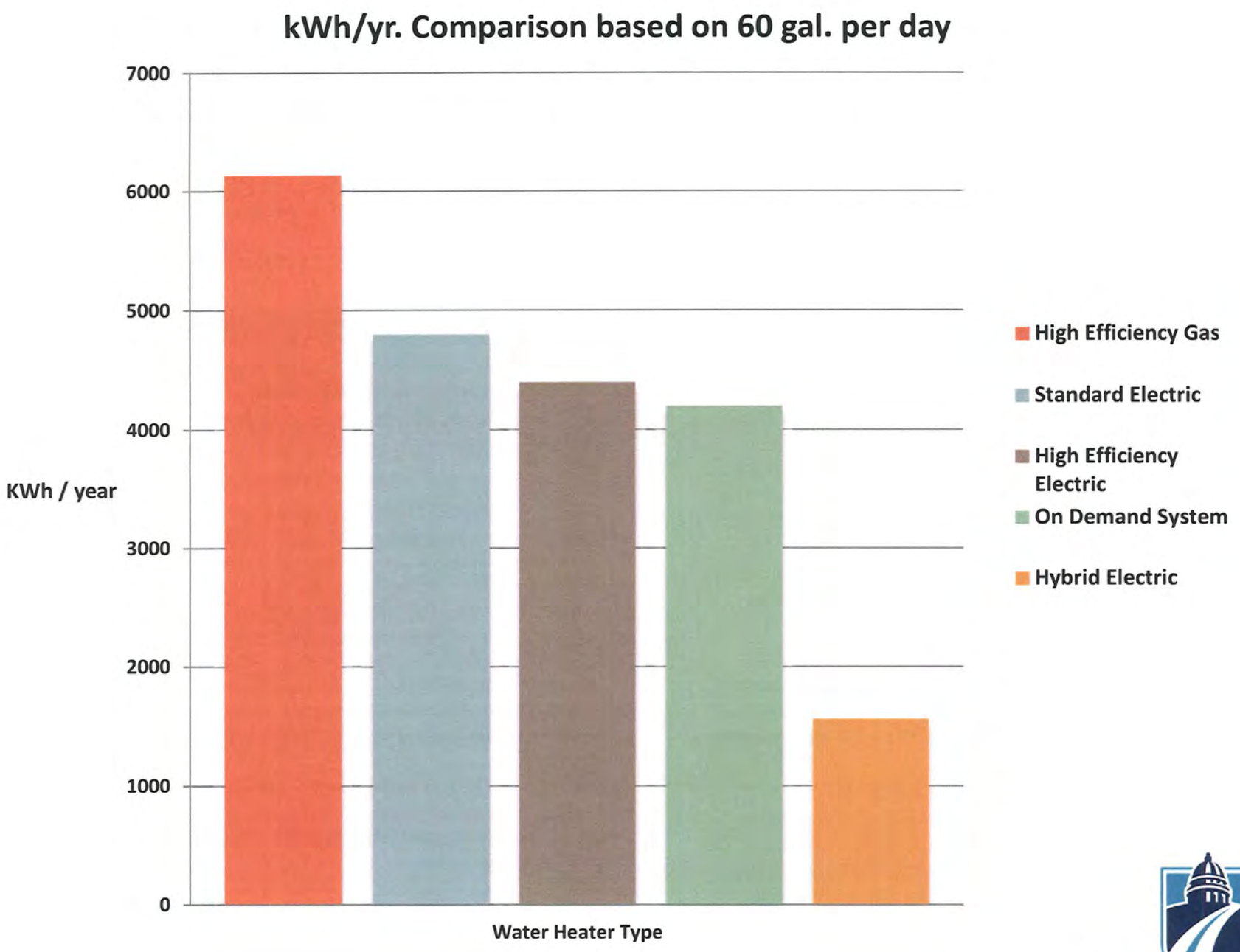
Our Recommendations

- We highly recommend the GE water heater. It utilizes heat pump technology, which pulls heat out of the air and puts it into the water held in the storage tank. This is why the EF is so high and the energy usage is so low. In times where the air temperature is less than 45 degrees F, the heat pump will shut off and an electric back up will heat the water instead. This will also occur in times of high hot water demand. In addition, the GE Geospring is manufactured in the USA.
- Our second recommendation is the A.O. Smith PCRT – 52. This is because it is capable of being powered by a PV system and the energy usage is somewhat low.
- Our third recommendation is the A.O. Smith GAHH – 50. It is cheap to operate but it uses a lot of energy. If the homebuyer decides to purchase the net-zero add on, the installation of this water heater would make it impossible for the home to be net zero.
- It should be stated that all of the water heaters listed are energy star qualified and they have a 50 gallon storage tank. They are all easy to install, user friendly and relatively low maintenance. Note that the initial cost excludes labor because the water heater is to be installed by the construction program at Madison College.

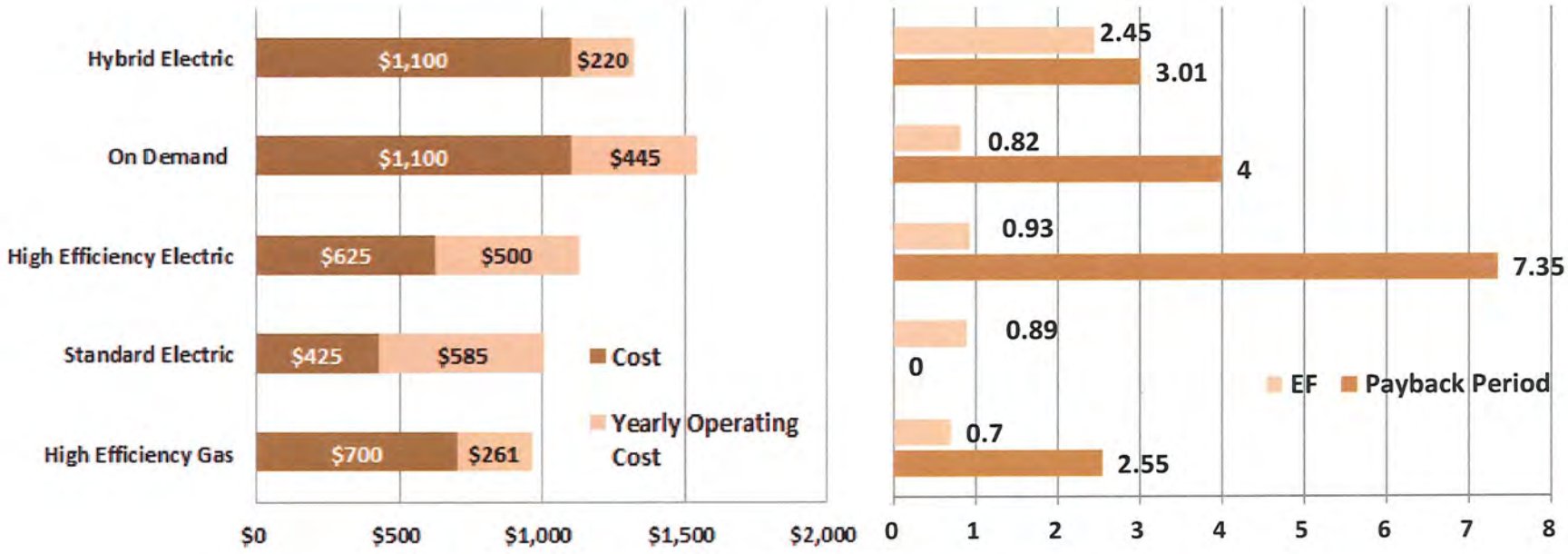
General

- Payback period was calculated based on the average cost of use of a standard electric water heater ($585/year)
  - Savings/year = $585 - other product
  - Example: $585 - $220 = $365/year in savings
  - Initial cost/savings = payback period
  - Example: $1100/$365 = 3.01 years
- Solar water heaters were discussed early on in the design process. The plan was to move the garage such that a solar panel for the water heater could be put onto the roof of it. This idea was thrown out, however, when we found out that it is against city building code to have the garage set back from the road too far. In addition, the uninstalled cost of the system (EF of 1.2) was around $4,500, and it must to be installed by a qualified contractor in order to maximize efficiency. The payback period was over ten years and the water heating system required routine maintenance.
- On demand heaters tend to work well in warmer climates and in homes with low hot water demand. Since the home is located in Wisconsin and the hot water demand might be high, tankless heaters were disqualified.

Water Heating – kWh/Year Comparison



Cost Comparison Table



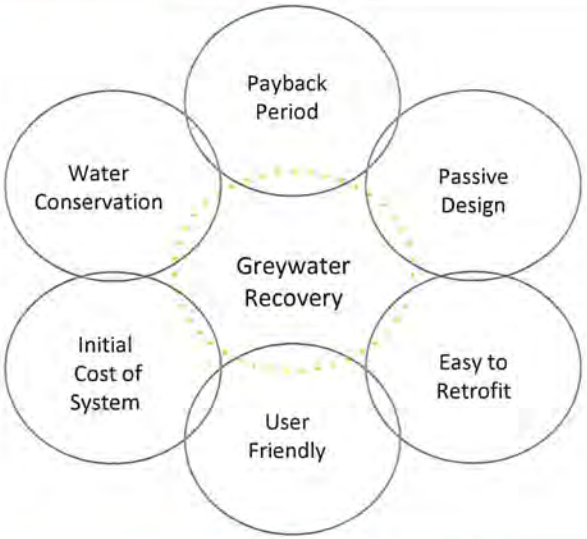
	High Efficiency Gas	Standard Electric	High Efficiency Electric	On Demand	Hybrid Electric
Cost	$700	$425	$625	$1,100	$1,100
EF	0.7	0.89	0.93	0.82	2.45
Yearly Operating Cost	$261	$585	$500	$445	$220
Payback Period	2.55	0	7.35	4	3.01

Chart Area

GREYWATER RECOVERY

ANDREW MULHERN

System Considerations



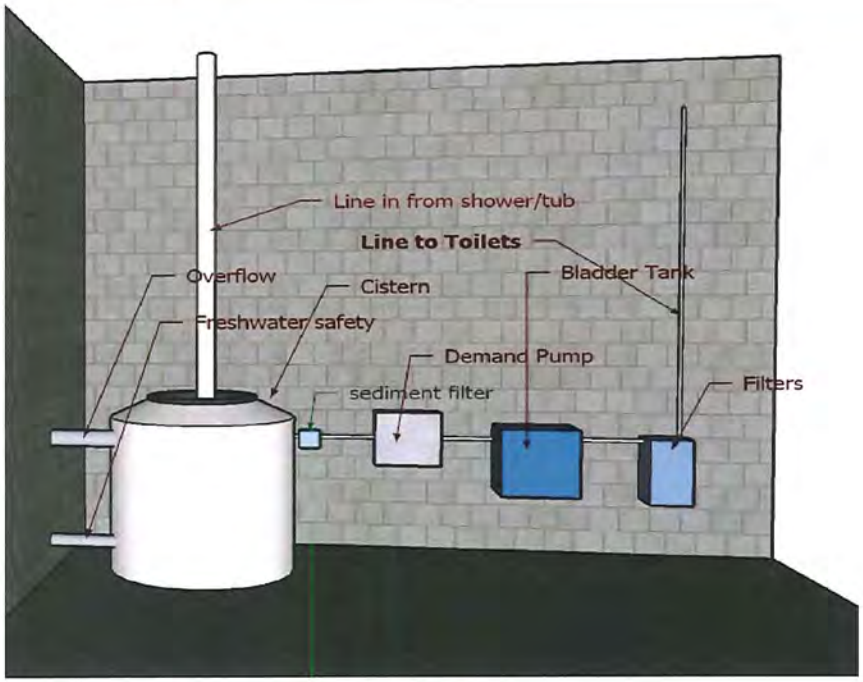
Description

- In a WI residence, there are three types of water; potable, greywater, and blackwater
    - Potable water is drinking water and water that comes out of the well
    - Greywater is water that could potentially be reused after a slight amount of filtration. Typically greywater is in the form of used shower water and laundry water
    - Blackwater is waste water from sinks and toilets and it is put directly into the septic
- The idea of a greywater system is to take that used water, filter it, and use it again before it becomes blackwater. It can be used for irrigation and for flushing toilets in WI. Since greywater systems don't necessarily come in a package, the components were specified and the system constructed as soon as we received permission to incorporate it into the design of the home

Design Considerations

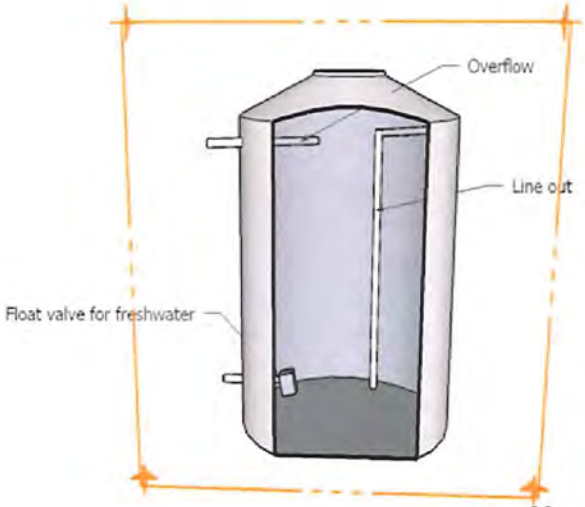
- The home will come with the plumbing for a greywater recovery system in place, making it easy to retrofit if the homebuyer decides to purchase the add on
- The system requires minimal maintanence
    - Homeowner only needs to clean and replace filters periodically and put chlorine into the holding tank
- All of the components of a greywater recovery system need to be cheap in order to keep the home under budget
    - The components of a greywater system vary between designs
    - The main components of this system include a cistern (main holding tank), a variety of filters, a water pump and a bladder holding tank
- All of the permanent parts of the greywater system should substantially outlast the calculated payback period of the system
- Since a greywater system is meant to conserve water and reduce the water bill, it was decided that it should also have a minimal impact on the energy bill. In other words, the system was designed with as much passive technology as possible
- In order to put the usefulness of a greywater system in perspective:
    - A typical 4 bedroom household uses 6-10K gallons of potable water per month. The bill for that ranges from $66 – $78 per month
    - A greywater recovery system will reduce water consumption by 1.3 – 2.5K gallons per month and sewer usage by 1.9 – 3.8K gallons per month
    - This alone will save the homeowner $51 – $102 per six months

System Layout



Design by Andrew J. Mulhern using Google SketchUp

- Used potable water from the residents' laundry and shower enters the cistern by traveling through a basket filter located in the tank opening (filter not shown)
- The demand pump then pumps greywater from the cistern through a sediment filter and into the bladder tank
  - Bladder tank works by pressurizing the water it is holding so when a toilet is flushed, the pump doesn't have to run in order for the toilet to refill
- Before greywater is put into the toilets, it travels through an additional filtration system:
  - The filtration system is composed of two filters
  - The first filter (bottom left) is a carbon filter that must be changed once every six months
  - The second filter (bottom middle) is a ceramic candle filter, which must be cleaned periodically and replaced only when it is detrimentally damaged
- Below is a cross sectional view of the cistern that will be incorporated in the greywater system. There will be a drain valve (not shown in diagram) at the bottom of the cistern in the event that the tank needs to be drained



Parts list

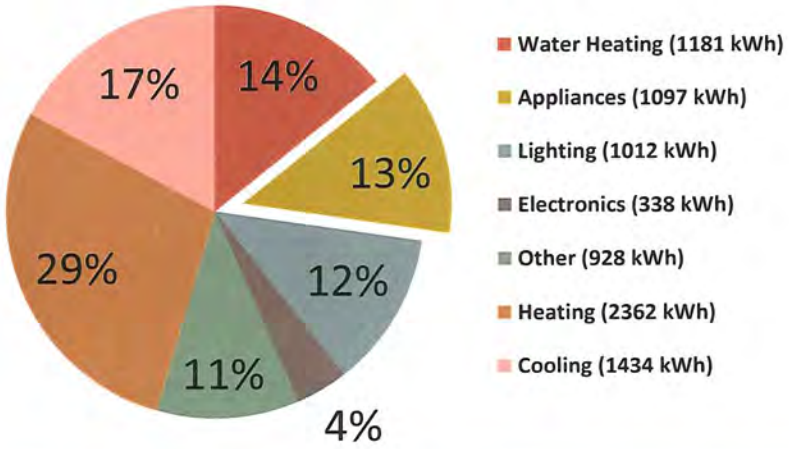
- **Cistern**
  - 130 gallon vertical tank
  - Float valve
  - Backflow preventer
  - Pressure fittings
  - Purge valve
  - Saltron Mini Spa Salt system chlorine generator (pictured)
    - System needs to be refilled once every 18 months with table salt
- **Demand Pump**
  - Shurflo demand pump- 1.1gpm, 60psi with 45psi bypass, ½" NPSM
- **Bladder Tank**
  - Waterworker 4 gallon pressurized bladder tank- 38psi precharged, max 100psig working pressure
- **Filtration system**
  - Doulton Rio 2000 Whole house system
    - Multi Candle Filter-cyst and bacteria
    - Neopure Carbon black cartridge – odor and chlorine
    - 2 Culligan 10" filter housing
    - Mounting Bracket
- **Cost of System**
  - The total cost of the system and all of the components will be around $900.00
  - The payback period will be around 9 years
    - Cost of system/minimum savings per year
    - Calculation: $900/$102 per year = 8.82 years

HOUSEHOLD APPLIANCES

MISTY PULCINE, DIANA KRAEMER

Brand Considerations

WI Average Annual Energy Use By Category



Brand Considerations

- In an effort to find the best cost to efficiency ratio, we have selected brand mismatched appliances. We have made an effort to match the kitchen appliances by ensuring that our selections are all available in stainless steel finish, which most homeowners seek.
- We recognize that some home buyers may not be satisfied with this decision, so if the CDA would prefer matching brands, we recommend Samsung appliances – though they may not always be the cheapest, they are known for their efficiency. The following data regards our selections with the assumption that brand matching is not a priority.

Our Recommendations

KitchenAid KDTE204DSS

Samsung WF45H6300AG

Samsung DV45H6300EW

Frigidaire FFHT2117PS

Samsung NE597N0PBSR

Compact Florescent Light Bulbs

Considerations

- Our house is designed for a family of 4, so only models with **capacity over four cubic feet** were considered.
- Our research showed that dryers have nearly all the same energy usage, so the burden of efficiency in a washer/dryer system lies with the washer
- Research shows that **front loading** machines are more efficient because they use gravity to move items through soapy water and have a larger capacity because they don't have an agitator in the drum.
- To ensure efficiency, we sought washers with a **high modified energy factor (MEF)** (cubic foot capacity/total energy use in a cycle) and **low water factor (WF)** (gallons per cycle/cubic foot capacity).

Comparisons

Brand	Model Number	Price	Capacity (c.f)	MEF (c.f./energy/ cycle)	WF (gal/cycle/ c.f.)	Average Energy Use (kWh/year)	Est. Water Use (gal.)	Features
Samsung	WF457A*GS**	$1,400.00	4.47	3.42	2.7	90	4731	21 washes, 6 temps
Samsung	WF433B*GJ**	$1,100.00	4.29	3.32	2.9	90	4868	13 washes, 6 temps
Samsung	**WF45H63**A***	**$990.00**	**4.47**	**3.42**	**2.7**	**90**	**4731**	**11 washes, 6 temps, stackable**
Samsung	WF42H50**A*	$720.00	4.16	3.2	2.9	95	4729	9 washes, 4 temps, Bad reviews
Whirlpool	WFW94HEA*+	$1,300.00	4.33	3.3	2.7	125	4583	11 washes, 4 temps, stackable

- Our selected washer has a great balance of features as well as a very high drum spin speed. We thought that more control over laundry wash cycles would be a great selling point as well as offer the most efficiency. Items can be washed as they need and not over or under washed. We also chose this model because it can be stacked with the dryer to save space.
- The more expensive options had even more washing features that we felt were unnecessary and not worth the additional cost. Their efficiencies were also not significantly greater.
- Our dryer choice is the matching dryer. It is $1070 and it is electric. It offers 3.5 lbs of clothing dried per Kw/hr. It also offers 14 different drying cycles and a moisture sensor.

Washer Specifications – Samsung WF45H6300AG

13 Preset Wash Cycles:
Eco Cold Wash, Normal, Heavy Duty, Permanent Press, Sanitize, Allergen, Bedding, Deep Steam, Active Wear, Delicates, Wool, Quick Wash, Rinse and Spin

13 Options:
SuperSpeed, Steam, Self Clean+, Delay End, My Cycle,
Prewash, Extra Rinse, Extra Spin, Spin Only, Sound, Child Lock, Smart Care, Drum Light

5 Temperature Settings:
Extra Hot, Hot, Warm, Eco Warm, Cold

5 Spin Settings:
Extra High, High, Medium, Low, No Spin

5 Soil Settings:
Heavy, Heavy Medium, Normal, Low Medium, Light

Dispenser Trays:
Prewash, Main Wash, Softener, Bleach

Warranty:
One (1) Year Parts and Labor
Two (2) Years Control Board
Three (3) Years Stainless Steel Drum
Ten (10) Years Direct Drive Motor

Fabric Care
14 Preset Dry Cycles
Steam Refresh, Steam Wrinkle Away, Eco Normal, Normal, Heavy Duty, Permanent Press, Bedding, Delicates, Wool, Sanitize, Time Dry, Air Fluff, Quick Dry, ActiveWear

9 Options
Mixed Load Bell, Wrinkle Prevent, Delay Start-Up to 24 Hours, My Cycle, Rack Dry, Adjust Time, Drum Light, Smart Control, Smart Care,

5 Temperature Settings
High, Medium, Medium Low, Low, Extra Low

5 Dry Levels
Very Dry, More Dry, Normal Dry, Less Dry, Damp Dry

2 Signal Sound Levels
On, Off

Accessories:
Stacking Kit

Product Dimensions & Weight (WxHxD)
Dimensions: 27" x 3811/16" x 34"
Weight: 231 lbs

Dryer Specifications – Samsung DV45H6300EW

13 Preset Dry Cycles:
Steam Refresh, Steam Wrinkle Away, Eco Normal, Normal, Heavy Duty, Permanent Press, Bedding, Delicates, Wool, Sanitize, Time Dry, Air Fluff, Quick Dry

11 Options:
Mixed Load Bell, Wrinkle Prevent, Anti-Static, My Cycle, Rack Dry, Adjust Time, Eco Dry, Sound, Child Lock, Smart Care, Drum Light

5 Temperature Settings:
High, Medium, Medium Low, Low, Extra Low

5 Dry Levels:
Very Dry, More Dry, Normal Dry, Less Dry, Damp Dry

2 Signal Level Settings:
On/Off

Warranty
One (1) Year Parts and Labor
Two (2) Years Control Board
Three (3) Years Stainless Steel Drum
Ten (10) Years Direct Drive Motor

Product Dimensions & Weight (WxHxD)
Dimensions: 27" x 38 11/16" x 32 3/8"
Weight: 126 lbs

Fabric Care
14 Preset Dry Cycles
Steam Refresh, Steam Wrinkle Away, Eco Normal, Normal, Heavy Duty, Permanent Press, Bedding, Delicates, Wool, Sanitize, Time Dry, Air Fluff, Quick Dry, ActiveWear

9 Options
Mixed Load Bell, Wrinkle Prevent, Delay Start-Up to 24 Hours, My Cycle, Rack Dry, Adjust Time, Drum Light, Smart Control, Smart Care,

5 Temperature Settings
High, Medium, Medium Low, Low, Extra Low

5 Dry Levels
Very Dry, More Dry, Normal Dry, Less Dry, Damp Dry

2 Signal Sound Levels
On, Off

Considerations

- We considered only **stainless steel** models in order to match the other kitchen appliances.
- Our research showed that a lot of dishwashers use about the same amount of energy, so we focused our searches on products that had **a large capacity** and plenty of features but still kept with the low energy usage.
- Our goals were to meet an **Energy Factor** (1/total energy needed) of at least .8 and a **Water Use** (gallons/standard cycle) of less than 3.
- Most cost variation was due to features rather than efficiency, so efficiency was not sacrificed by selecting an affordable model.

Comparisons

Brand	Model Number	Price	Annual Energy Use (Kwh/yr)	Energy Factor	Water Use
Electrolux	EI24ID30***A	$720	260	0.85	2.48
Thermador	DWHD651J**	$2,200	260	0.83	2.85
Thermador	DWHD650J**	$1,700	260	0.83	2.85
Bosch	SHV9PT5***	$1,700	239	0.89	2.95
KitchenAid	**KDTE204D*** **	**$900**	**260**	**0.85**	**2.90**
Samsung	DMT610***	$849	279	0.80	4.00

- Because nearly all of our options had the same annual energy usage, we found the best Energy Factor and Water usage we could for the price. This would seem to indicate the Electrolux as the best choice. However, further research indicated poor customer reviews. Users complained about it starting without being prompted, temperamental controls, being too small and breaking in general. Taking that into consideration, we recommend the KitchenAid.
- The KitchenAid has a rebate that saves $150 if the appliance is bought before July 14th, 2014. This rebate is offered at Brother's Main Appliances, a local business.
- The KitchenAid also has a much larger capacity than the Electrolux. Additionally, this model is 15% better than the U.S. standard for annual energy usage and 41% better than the standard in water consumption.

Our Recommendation – KitchenAid KDTE204DSS

Water Filtration System
Removable Filter
Number of Wash Cycles
6
Delay Wash
Yes
Energy Star® Qualified
Yes
Cycle Selections
Express Wash, Light, Normal, ProWash™, Rinse Only, Tough
Option Selections
4 Hour Delay, Control Lock, Heated Dry, Hi Temp Wash, Sani Rinse®
Capacity
14.0 Place Settings
Number of Racks
3
ADA Compliant
No
Rack Material
Nylon
Control Type
Electronic Capacitive Touch
Upper Adjustable Rack
2 Positions
Tub Material
Stainless Steel
Silverware Basket Type
Full Length, Non Splitable
Rack Material
Nylon
Tub Material
Stainless Steel
Decibel Level
45
Lower Rack Extras
No
Upper Rack Extras
1-Plastic Cup Shelf, 2-Light Item Clips, 4-Stemware Holders
Dimensions
Product Height
34 1/2
Depth With Door Open 90 Degree
49 1/2
Maximum Height
34 1/2
Product Width
23 7/8
Product Depth
24 3/4
Minimum Height
33 1/2

Considerations

- We considered only **stainless steel** models in order to match the other kitchen appliances.
- Our research indicated that of the four types (side-by-side, top freezer, bottom freezer, and French door), **top freezer** models are the most efficient
- On average, **Samsung** is the most efficient brand. Though we did not recommend a Samsung model in this case, they are known for their refrigerator efficiency and reliability.
- The average capacity of refrigerator/freezer for an American family of four is **18-25 square feet**, so only models within this range were considered
- **Efficiency over features**. We wanted to focus on the cost to efficiency ratio and disregard those who were higher prices simply because of added features.

Comparisons

Brand	Model Number	Cost	Type	Capacity (cu. ft.)	Energy (kWh/year)	Ice and Water	Notes
Samsung	RS25H5111SR	$1,699.00	Side by Side	24.5	634	External	
Samsung	RF24FSEDBSR	$3,699.00	French Door	23.6	474	Filtered External	Double Bottom Drawer
Samsung	RF221NCTASR	$1,899.00	French Door	21.6	433	Filtered Internal Ice	
Whirlpool	WRT371SZBM	$1,199.00	Top Freezer	21.1	364	None	Questionable Reviews
Frigidaire	**FFHT2117PS**	**$829.00**	**Top Freezer**	**21.1**	**408**	**Optional**	**4 star reviews**
LG	LTC20380ST	$999.99	Top Freezer	20.2	406	None	Reviews - Door seal issues

- Many models were more expensive but not more efficient. Of the affordable, efficient top freezer models, many received poor reviews. Door sealing issues will effect efficiency, so we do not want to select those models. The most affordable model considered was also the most efficient and had excellent reviews, so we are recommending that Frigidaire model.

Our Recommendation – Frigidaire FFHT2117PS

GENERAL SPECIFICATIONS

- Power Type: Electric
- Size: 21 Cu. Ft.
- Installation Type: Free-Standing
- Collection: Frigidaire

Electrical Specifications

- Amps @ 120 Volts: 6.0
- Minimum Circuit Required (Amps): 15A
- Power Supply Connection Location: Right Rear Bottom
- Voltage Rating: 120V, 60Hz

Certifications & Approvals

- ADA Compliant: No
- CSA Certified: Yes
- ENERGY STAR® Certified: Yes

Exterior Specifications

- Door Style: UltraSoft™
- Door Finish: Stainless Steel
- Reversible Door: Yes

Freezer Specifications

- Fixed Freezer Shelves: 1 Full-Width

Exterior Dimensions

- Case Depth: 28-3/4"
- Depth with Doors (no Handles): 32"
- Depth with Doors and Handles: 34-1/2"
- Case Height: 68-5/8"
- Height with Hinges and Covers: 69-3/8"
- Case Width: 29-7/8"
- Depth: 32"
- Depth (with Door 90° Open): 60"
- Height: 69-3/8"
- Width: 30"

Ice Maker

- Ice Maker: Optional

Considerations

- We considered only **stainless steel** models in order to match the other kitchen appliances.
- Our biggest consideration for the range model was the **gas versus electric** debate.
- Gas ranges are less expensive and more efficient than electric ranges in general. They are also user friendly and considered high end and desirable. Unfortunately, a gas range would require external venting which would critically damage the envelope of the house and tax the HVAC system. We determined that maintaining the envelope outweighed the benefits of selecting a gas range.
- With the electric range, we can utilize a recirculating fan and preserve the envelope of the house. Among electric ranges, the **induction stove top and convection oven** are the most efficient type. These efficient models can be quite expensive, and the convection oven has a steep learning curve which the average homeowner may not appreciate. A big benefit to electric ranges is that their energy use is much easier to offset with solar than gas ranges.

Comparisons

Brand	Model Number	Type	Capacity (c.f.)	Burners (Watts)	Convection element (Watts)	Bake Element (Watts)	Broil element (Watts)	Cost
GE	JGBS60REFSS	Gas with electric start	4.8	3663, 2784, 2784, 1465	N/A	5275	5275	$640
Premier	P30S330BP	Gas with electric start	3.9	4396, 2667, 2667, 1758	N/A	4982	4982	$1,549
Samsung	NE595N0PBSR/AA	Induction/Convection	5.9	3400, 3000, 2300, 2300	800	3000	3800	$1,699
Electrolux	EI30IF40L	Induction/Convection	6.0	4000, 2540, 2540, 1000, 120	350	3500	4000	$1,999
Samsung	**NE597N0PBSR**	**Induction/Convection**	**5.9**	**3000, 3000, 1200, 1200, 100**	**800**	**3000**	**3800**	**$1,999**
Whirlpool	WFI910H0AS	Induction/Convection	6.2	3700, 3200, 1800, 1800	914	3600	3600	$1,799

- There were many comparable induction/ convection ranges available, so we selected the Samsung model because it was a reliable brand, and received high reviews.
- All of the electric models included a self-cleaning feature which we would strongly advise the home owner against using as it can be a serious drain on power.
- Though energy use did not vary greatly between the models considered, a few options were ruled out for their energy consumption.

Our Recommendation – Samsung NE597N0PBSR

Physical Specifications

- 5.9 cu. ft. Oven Capacity
- Product Weight: 84.8 kg (186.95 lbs)
- Shipping Weight: 96 kg (211.64 lbs)
- 1.4 cu. ft. Warming Drawer
- Cavity dimensions: 25.00" x 20.78" x 18.94"
- Outside dimensions: 29.91" x 47.06" x 25.97"

Performance

- Convection: Yes (3-Fan True Convection, 800 W)
- Broil Element: Yes (3800 W, 6 Pass)
- Bake Element: Yes (3000 W, 8 Pass)
- Self Clean
- SteamQuick

Cooktop

- Induction cooktop
- 4 Burners (3 ea w / FlexCook Zone)
- Burner Specs:
  7" (2300 W, Boost)
  9" (3000 W, Boost)
  11" (3400 W, Boost)
  FlexCook Zone (2 x 9", 4600 W)
- Hot Surface Indicator
- Boil Alert

General Feature

- 4 Glass Layers
- Premium Tinted Windows
- Hidden Bake Element
- Wide Glass Touch / Digital LED Display
- Number of Racks: 3 (w / 1 split rack)
- Number of Rack Positioning: 7
- Warming Drawer: Yes (600 W)
- Sabbath Mode

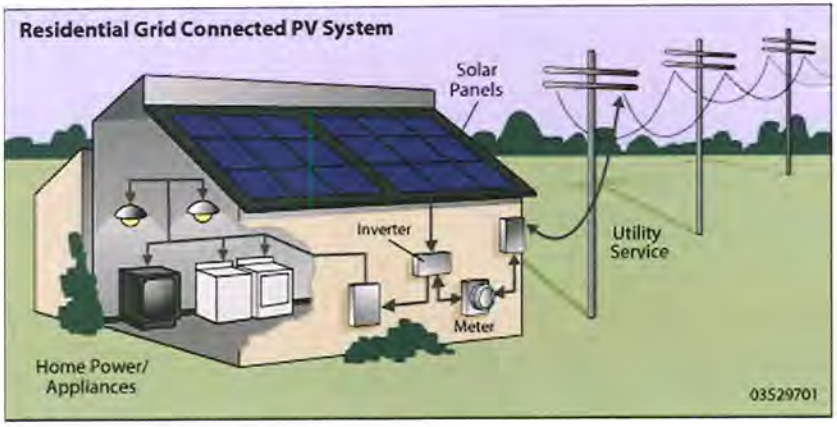
Comparison

Recommendation – Compact Florescent

- Ideally, we would like to use LED bulbs throughout the house. However, LED bulbs are very expensive so we are recommending **compact fluorescent bulbs (CFL)** be installed initially. CFLs can be bought through Aliant Energy for an sizable discount. If the homeowner wants, they can switch to LED bulbs at a later date.

PHOTOVOLTAIC (PV) SYSTEMS

ROMAN MORSE, ASHLEY FULLER, JESSE POLLOCK, MAX SCHLOEMER, DEVIN HUNTER



PV Description

- An active solar electric system takes thermal radiant energy from the sun and converts it into direct current (DC) electricity with the use of semiconductors, typically silicon
- Photons from the sun interact with the silicon panels and excite electrons. The electrons are then able to be pulled along a wire and used to power electric devices throughout the home.
- The components that make up a PV system are the solar panels, inverters, an AC disconnect, and a meter
- Assuming the sun will stay put for some time, this is an excellent choice in renewable onsite energy as the cost per module has decreased dramatically over time while efficiencies continue to rise.

Design Considerations

- Energy consumption < Energy Production
  - In order for this home to truly be "net-zero" we will need to completely offset any onsite energy consumption (electricity or natural gas) with onsite energy production
  - Average energy usage in Wisconsin per house hold is just over 10,000 kwh per year
  - Assuming the home is designed to be energy efficient, 8000 kWh per year is the target for solar production. This should make the home at least close to net zero
- Home design
  - Roof material
    - Choosing a metal roof over a shingled roof makes the PV system much more practical and user friendly. The life span of the solar panels is around 25 years and they will outlive a shingled roof. This means that if the homeowner must re-shingle their roof, the entire PV system must come down first.
  - Roof pitch and Orientation of home
    - Dimensions for south facing roof: 46' 11" x 15' 2"
    - Slope: 40 degrees
    - The pitch of the roof and the orientation with respect to 180 degrees south were the two largest factors we had to consider when choosing between mono crystalline and polycrystalline PV panels
- Climate
  - Cold: solar panels work more efficiently in cold weather. The panels themselves may become hot during the warm summer and this leads to a slight decrease in efficiency
  - Snow: When specifying and recommending parts, we had to make sure that the parts were able to withstand our winters here in Wisconsin. This means being able to carry a heavy load of snow and being able to withstand high winds
- Shading/Partial shading
  - When a solar system on a string inverter has one or more of its panels shaded, the entire system fails. Since partial shading could potentially be an issue in the future, we considered this while choosing the best inverters for our system.
- Cost
  - Routine maintenance on the panels should be minimal and the initial cost of the PV system has dropped dramatically.

PV Panel Comparison

Provider	Model	Cell Type	Module Efficiency
Sharp	ND-250 QCS	Polycrystalline	14.7%
Solar World	SW-255 2.5	Monocrystalline	15.2%
Canadian Solar	CS69-255	Monocrystalline	16.7%
Astroenergy	CHSM 6610P	Polycrystalline	15.5%

Panels

- Monocrystalline
  - Crystal structures are all aligned in one direction
  - Clean black surface
  - Best for climates with a lot of day time or for a non-fixed system
- Polycrystalline
  - Slightly less efficient because the crystal structures do not align perfectly
  - More production than monocrystalline when the sun is lower in the sky
  - Better for climates with average amounts of sun or for fixed systems
  - Shimmery blue surface

Inverters

- String
  - One string inverter may be used to convert the entire system's DC to AC
  - Best used in climates with constant sunlight
- Micro
  - Placed on each individual panel and will convert that panel's DC to AC
  - Best used in areas where the amount of sunlight varies and there is possibility for partial shading

Estimates

Provider	System Size	Panels	Inverter	Install	Initial Cost	State Solar Credit	Federal Tax Credit	Subtotal Estimate
Full Sprectrum	8.16 kW	Solar World	SMA SB6000US- String	yes	$23,201	$2,400	$6,960	$13,840
H&H Solar	8.16 kW	Solar World	none recommended	yes	$31,440	$2,400	$9,432	$19,608
Whole Sale Solar	8.16 kW	Astroenergy	Emphase microinverter	no*	$15,851	$2,400	$4,755	$8,695

*Madison College's PV team is capable of install

Payback Times

Provider	Estimated Power Output	Estimated Energy Value	Estimated Subtotal	Payback Time
Full Spectrum	9,854 kWh	$1,286	$13,840	10.76 years
H&H Solar	9,854 kWh	$1,286	$19,608	15.25 years
Whole Sale Solar	9,854 kWh	$1,286	$8,695	6.76 years

General Notes

- Here are three companies that provided quotes for the PV system. The final choice of system rests with the CDA
- The homeowner pays $0.13/kWh for electricity off of the grid
- Below is the breakdown of how the payback period was calculated
  - (estimated cost of solar array) – (state and federal tax credits) = subtotal
  - (system size) x (1206* sun hours per year) = energy output in kWh per year
  - (energy output) x ($0.13* per kWh) = annual price of energy output
  - (subtotal) / (annual price of energy output) = payback period in years

*1206 is a conversion factor
*$0.13: cost of electricity through MG&E

Location and Station Identification

Requested Location:
2147 Dunn Marsh Terrace

Weather Data Source:
MADISON DANE CO REGIONAL ARPT [ISIS], WI (TMY3)

Latitude:
43.13° N

Longitude
89.33° W

PV System Specifications

DC Rating:
6.63 kW DC to AC

Derate Factor:
0.77

Array Type:
Fixed (open rack)

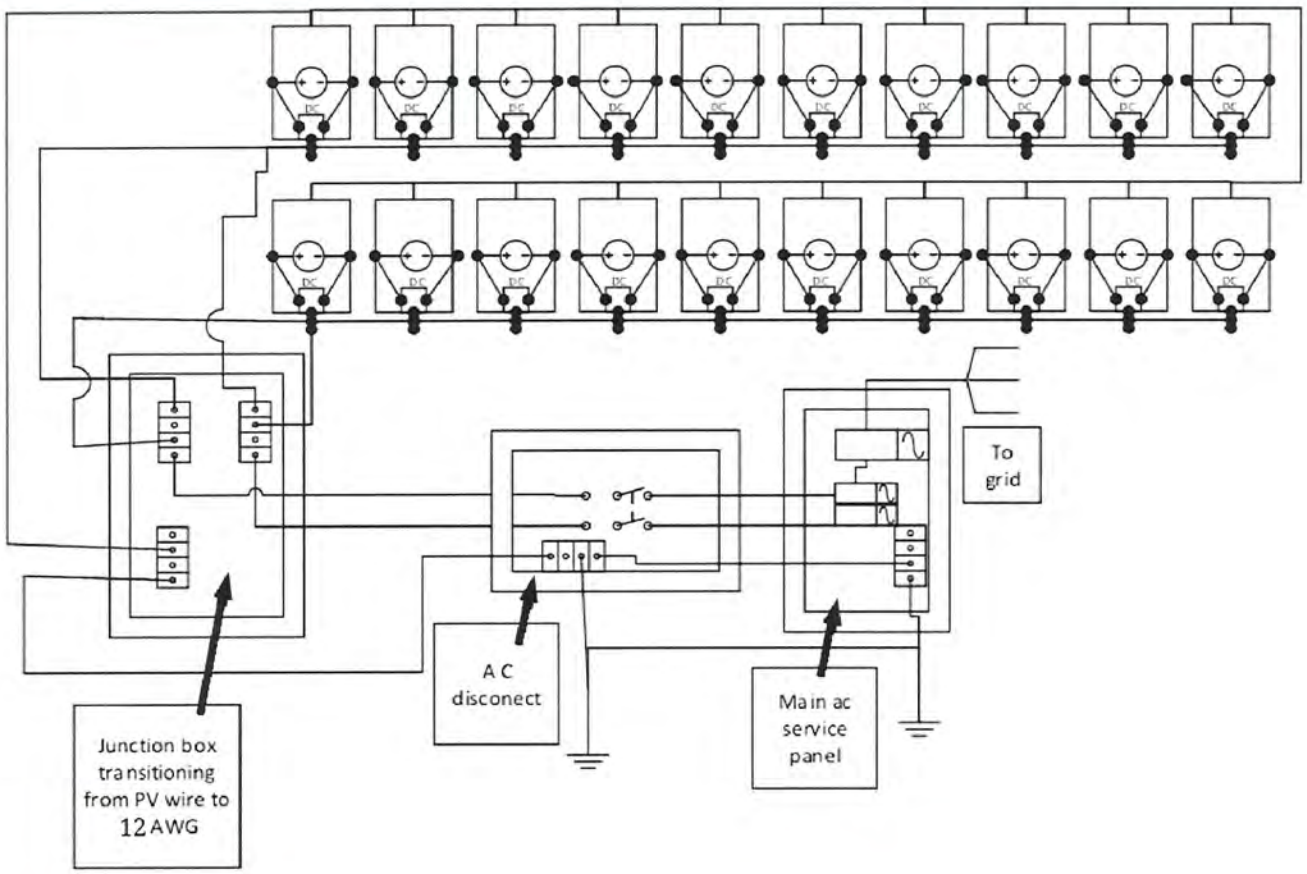
Array Tilt:
40°

Array Azimuth:
180°

Production by Month (PV Watts)

Month	Solar Radiation (kWh / m2 / day)	AC Energy (kWh)	Energy Value (Dollars)
January	3.00	633	85
February	3.74	697	94
March	4.32	845	114
April	5.10	924	125
May	5.90	1,064	144
June	6.29	1,076	145
July	6.13	1,074	145
August	5.74	1,009	136
September	4.88	838	113
October	3.71	692	93
November	2.63	492	66
December	2.48	509	69
Total	**53.89**	**9,854**	**1,286**

System Diagram



Explanation

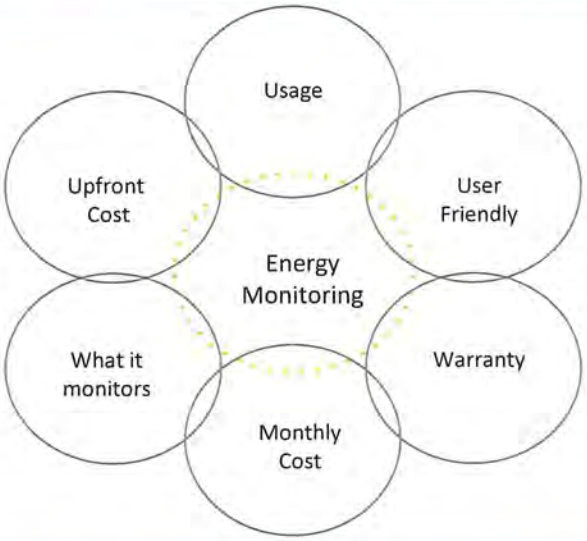
- Here is a blueprint regarding what the PV system will look like. On the top of the schematic are the solar panels and the black dots connected to the panels are microinverters, which are to be installed on each panel in order to maximize production hours. Then there are wires leading to a junction box, an AC disconnect, and to the main service panel, before being connected back to the grid.

3-D Rendering

ENERGY MONITORING SYSTEMS (EMS)

ANTHONY MIKELL, JACQUERAH JOLLY

Design Considerations



Energy Monitoring Description

- An Energy Monitoring System is a way in which a computer software system and its hardware components link to an external server that can track the energy usage of a household. This is important to consumers, as it reduces the amount of money they spend on energy bills. An EMS also makes the homeowner aware of how much energy is wasted in a day, effectively encouraging them to practice energy conservation techniques. Energy monitoring systems can cut energy usage by up to 30%.

General Guidelines

- EMS can monitor gas, solar, electric, wind, water, and geothermal systems
- Can be wireless monitoring throughout the home or wired monitoring depending on how much the consumer wants to pay
- Needs a computer to analyze the data in your home with the software provided by the EMS
- Depending on the software, consumers can have various features
    - Getting alerts via text or email regarding unusual usage
    - A history of the homeowner's usage to compare past years to present
    - Monitors energy usage by minutes and some systems monitor by seconds.
    - The ability to set an energy usage limit on a certain circuit. This works by notifying the homeowner when the limit is being approached as well as when they exceed their limit
    - The ability to view energy consumption on each individual circuit in order to determine which circuits are using more energy than others
    - The EMS should be capable of monitoring energy production and comparing it to consumption amounts
- Energy usage data can be accessed anytime and anywhere as long as there is internet available

Energy Monitoring Systems Considered

Brand	Cost	Monitors	Maintenance	Wifi or Ethernet	Customer Friendly	Warranty	Portable	Contracts	Can we install?
Wattvision	$249 for meter	Solar, HVAC, Electric, Water	$5.99/month	Wifi	Yes	No	Yes	No	Yes
Insteon	$200 for software $40/Plug	HVAC, Electric	No	Both	No	No	Yes	No	Yes
Brultech	$350-600 Depends on breakers	Solar, HVAC, Electric, Water, Gas	No	Both	Yes	No	Yes	No	Yes
Powerhouse Dynamics	$600-900	Solar, HVAC, Electric, Water, Gas	Yes	Wifi	Yes	No	No	Yes/ 2 years	No
Enerati	n/a	Power, Renewable Energy, Backup Power, Water, Gas, Temperature	Free - $5	Wifi	Yes	No	No	No	No
eGuage	Free	House Consumption, Solar, Wind, Renewable Electric, Individual Load	No	Wifi	Yes	No	Yes	No	Yes

Energy Monitoring System Recommended

- After looking through various EMS, the features are almost the same throughout each company. They can all monitor energy usage and they all provide tips on energy reduction. What can make the difference in each system is cost of installation and additional features. The purchase of an EMS is based of off what the consumer needs to monitor, how to minimize installation costs, and how that system will help reduce the amount of energy used.
- We would recommend the Wattvision EMS. This allows the homeowner to choose between monitoring their home using Wattvision's initial digital meter and monitoring individual circuits throughout the house. The whole house monitoring setup costs $250 while the individual circuit upgrade costs $6.00 per month. Wattvision also provides a unique comparison with other system users in order to see who is saving more energy. This creates competition between Wattvision users, which could potentially drive the homeowner to conserve more energy as time goes on. Furthermore, Wattvision users can get helpful tips on energy reduction from the Wattvision community.

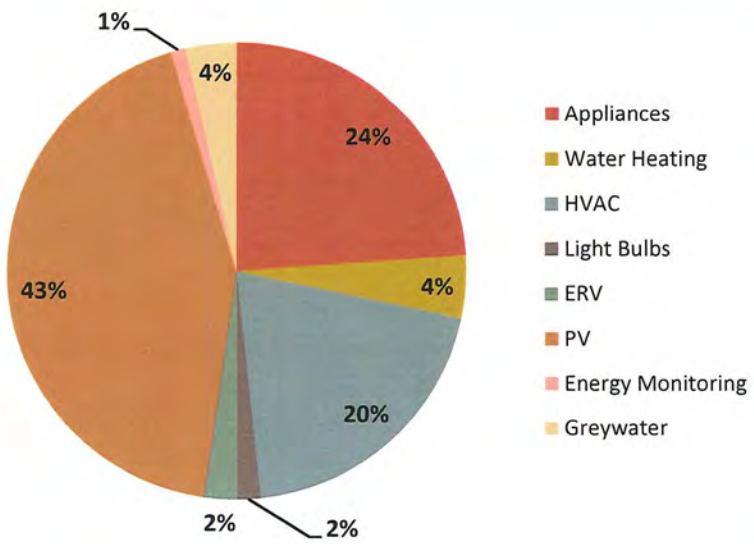
BUDGET ESTIMATIONS

PEDAR HAYES, ERIC BENSON

Madison Community Development Authority Financial Budget

House System	Cost
Base Items	
HVAC	$ 5,000
HRV / ERV	$ 575
Appliances	$ 5,940
Water Heating	$ 1,100
Light Bulbs	$ 400
Optional Items	
Solar P.V.	$ 10,730
Energy Monitoring	$ 250
Grey Water	$ 900
Base Total :	$ 13,015
Total of Optional Items :	$ 11,880
Net Total :	$ 24,895

Portions of Financial Budget Including Add – Ons



Energy Budget

House System	Avg. Energy Use (kWh/yr.)	Ext. Condition Usage (kWh/yr.)
HVAC	2,700	3,200
HRV / ERV	1,360	1,360
Lighting	435	435
Water Heating	1,830	1,830
Appliances	2,500	2,500
Greywater	30	30
Energy Monitoring	15	15
Photovoltaic	(- 9,850)	(- 9,850)
Total Produced :	(- 9,850)	(- 9,850)
Total Used :	+ 8,870	+ 9,370
Net Usage :	(- 980)	(- 480)

COMPANY RESOURCES

RenewAire

RenewAire

The Natural Choice for Fresher Air

Frigidaire

FRIGIDAIRE

General Electric

Mitsubishi Electric

Samsung Appliance

SAMSUNG

KitchenAid Appliance

REFERENCES

Water Heating Sources

- **Information Regarding A.O. Smith Water Heaters**
  - http://s3.pexsupply.com/product_files/PCRT-52-Brochure.pdf
  - http://www.pexsupply.com/AO-Smith-GAHH-50-50-Gallon-40000-BTU-Effex-High-Efficiency-Residential-Gas-Water-Heater
- **Information Regarding GE GeoSpring Water Heater**
  - http://www.geappliances.com/heat-pump-hot-water-heater/
  - http://www.sears.com/ge-geospring-trade-hybrid-water-heater/p-04232200000P?sid=IDx01192011x000001&kpid=04232200000&kispla=04232200000P&sid=IDx20131030xMPAPxCPA28
  - http://www.bpa.gov/energy/n/emerging_technology/pdf/HPWH_Lab_Results_Advisory_Team_7-14-11.pdf
- **Energy Efficient Water Heating Factsheet**
  - http://www.energy.wsu.edu/documents/AHT_Efficient%20Water%20Heating.pdf
- **Information Regarding Solar Water Heaters**
  - http://energy.gov/energysaver/articles/solar-water-heaters
  - http://www.energystar.gov/index.cfm?c=solar_wheat.pr_savings_benefits
- **Infographic Containing General Guidelines for Selecting a Water Heater**
  - http://energy.gov/articles/new-infographic-and-projects-keep-your-energy-bills-out-hot-water

ERV – Energy Recovery Ventilation Sources

- **RenewAire ev200**
  - http://www.soundgt.com/EV130&200Manual.pdf
  - http://www.renewaire.com/
- **Venmar AVS 1.2**
  - http://www.venmar.ca/DATA/DOCUMENT/29_3_en~v~Specification_Sheet.pdf
  - http://www.venmarces.com/
- **Zehndr comfoair 350**
  - http://zehnderamerica.com/wp-content/uploads/2014/02/CA-350-Specification.pdf
  - http://zehnderamerica.com/

HVAC Sources (not integrated into presentation)

- **Mitsubishi Contracter Guide**
  - http://www.mitsubishipro.com/media/382145/m-series_revised_july13.pdf

Greywater Sources

- **Everything There is to Know About Greywater Recovery Systems and the City of Madison's Water Data**
  - http://water.epa.gov/scitech/wastetech/upload/Evaluation-of-Energy-Conservation-Measures-for-Wastewater-Treatment-Facilities.pdf
  - https://www.cityofmadison.com/water/contact/billing.cfm

PV Sources

- **Specification of PV Panels and Inverters**
  - http://www.altenergy.org/
  - http://pvwatts.nrel.gov/
  - http://rredc.nrel.gov/solar/calculators/pvwatts/version1/derate.cgi
  - http://www.pveducation.org/pvcdrom/solar-cell-operation/effect-of-temperature
  - http://www.sunergysystems.com/residential-solar/faq
  - http://www.fsec.ucf.edu/en/consumer/solar_electricity/basics/how_pv_cells_work.htm

- **Solar Analysis**
  - http://www.solar-estimate.org/
  - http://www.nrel.gov/

- **Estimates**
  - http://www.wholesalesolar.com/
  - http://www.fullspectrumsolar.com/
  - http://www.hhgroupholdings.com/pages/Solar/Home-Page.php

- **Solar Credits and Buybacks**
  - http://www.dsireusa.org/
  - http://www.mge.com/customer-service/home/elec-rates-res/clean-power.htm

Washer:
Specifications list:
http://www.samsung.com/us/system/consumer/product/wf/45/h6/wf45h6300aga2/WF45H6300AG_F.pdf
Original Search File*:
https://data.energystar.gov/Government/ENERGY-STAR-Certified-Residential-Clothes-Washers/cmae-djp4

Dryer:
Specifications list:
http://www.samsung.com/us/system/consumer/product/dv/45/h6/dv45h6300ega3/DV45H6300EG_F.pdf

Dishwasher:
Specifications list:
http://www.kitchenaid.com/shop/major-appliances-1/dishwashers-2/dishwashers-3/-[KDTE204DSS]-406919/KDTE204DSS/
Original Search File (To use this file, you simply enter the parameters that you want and the file sorts the options automatically. Doing so does not change the URL.):
https://data.energystar.gov/Government/ENERGY-STAR-Certified-Residential-Dishwashers/58b3-559d

Reviews:
http://www.homedepot.com/p/Electrolux-IQ-Touch-Top-Control-Dishwasher-in-Stainless-Steel-EIDW5705PS/204151200#customer_reviews

Light Bulbs:
http://www.scientificamerican.com/article/buying-better-bulb/

Refrigerator:

Average size for family of 4 is 18-25 sqr feet http://www.csmonitor.com/Business/2012/0103/Six-steps-to-choosing-the-best-refrigerator/Choose-your-size

Size does not greatly impact efficiency http://enervee.com/fridgescore/

Top freezer is most efficient http://enervee.com/fridgescore/

On average Samsung is most efficient http://enervee.com/fridgescore/ and http://www.treehugger.com/clean-technology/samsung-leads-energy-efficiency-rankings-refrigerators.html

Could save thousands PER YEAR with an efficient refrigerator. http://www.treehugger.com/clean-technology/samsung-leads-energy-efficiency-rankings-refrigerators.html

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Refrigerator Cont.:

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Range:

Gas stove with electric ignition is most efficient http://home.howstuffworks.com/gas-vs-electric-stoves2.htm

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