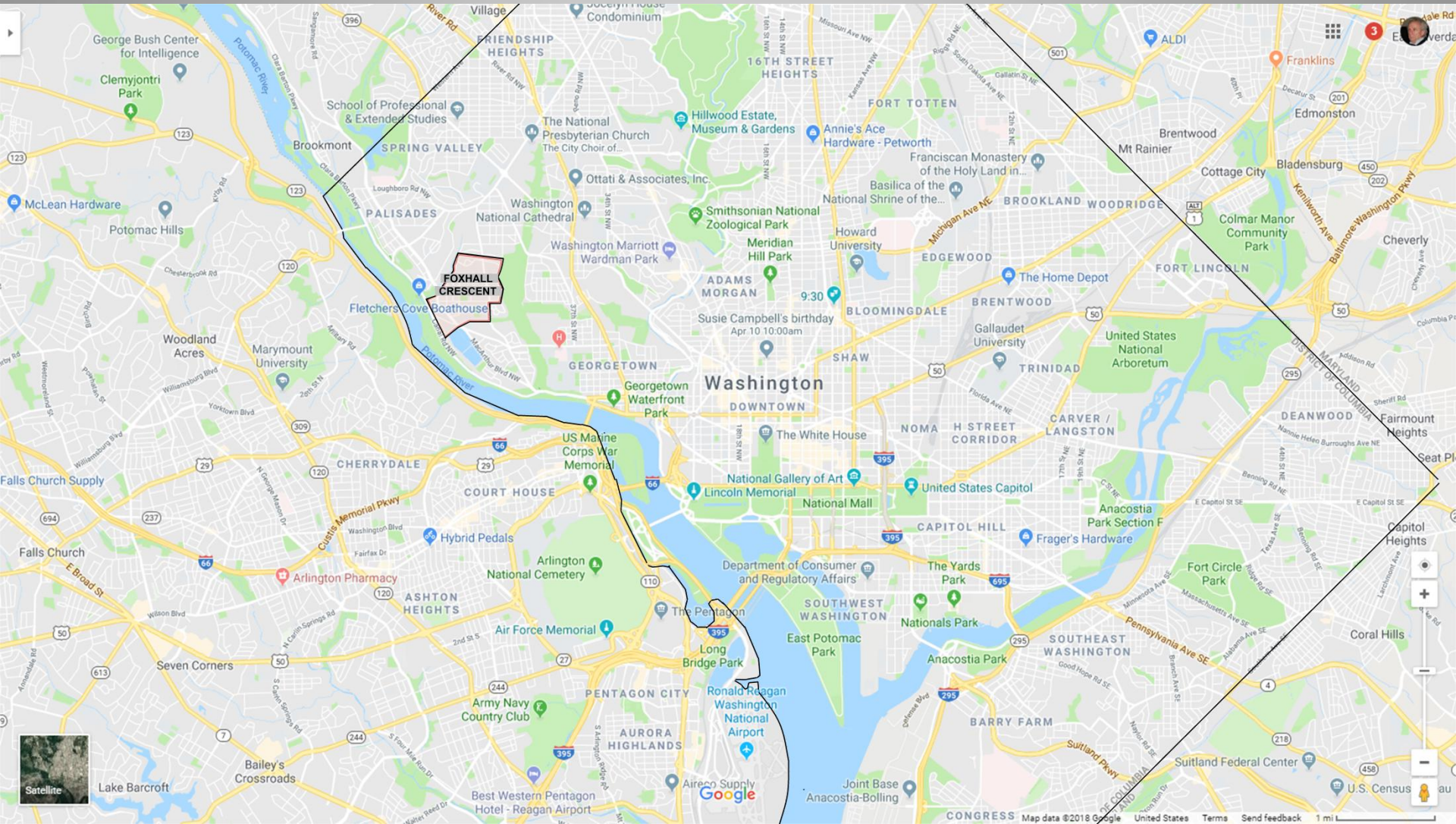


ENSER MORRIS HYBRID PV/THERMAL HEAT PUMP SYSTEM

AEE 2017 INTERNATIONAL INNOVATIVE ENERGY PROJECT OF THE YEAR AWARD





ENSER MORRIS PROJECT LOCATION MAP FOXHALL CRESCENT NEIGHBORHOOD , NW, WASHINGTON, DC 20007



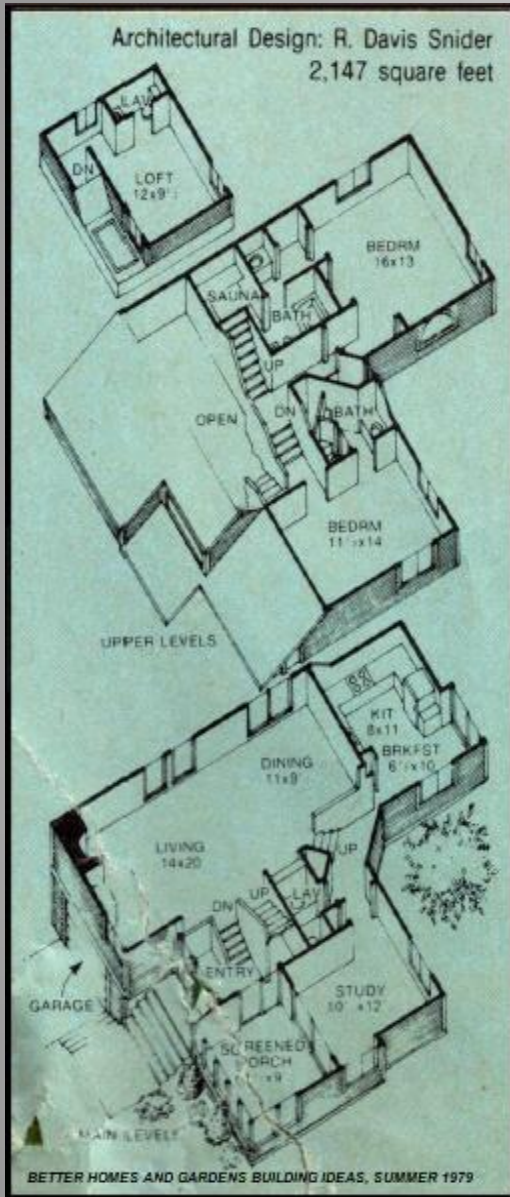
DC GIS OBLIQUE ANALYST DCOCTO SANBORN AERIAL

04/01/2015 PHOTO – NEW ROOF

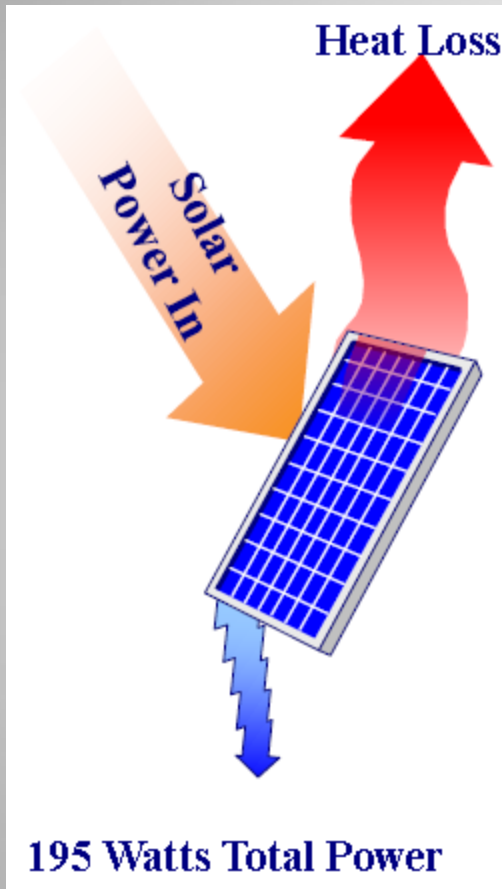


DC GIS – DC ATALS 2017 AERIAL PHOTO IMAGE

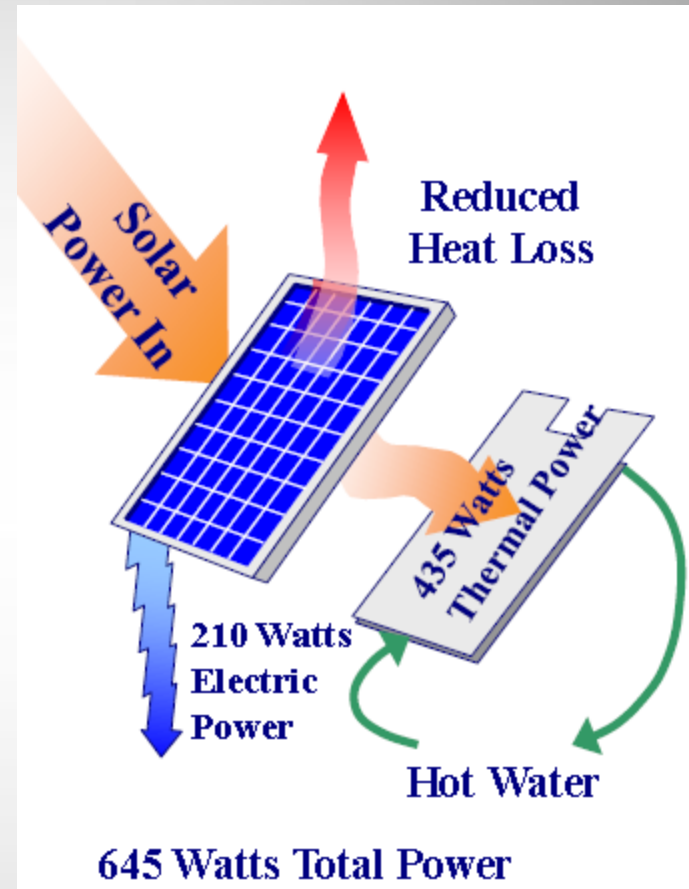
2017 PHOTO - COLLECTOR ARRAYS



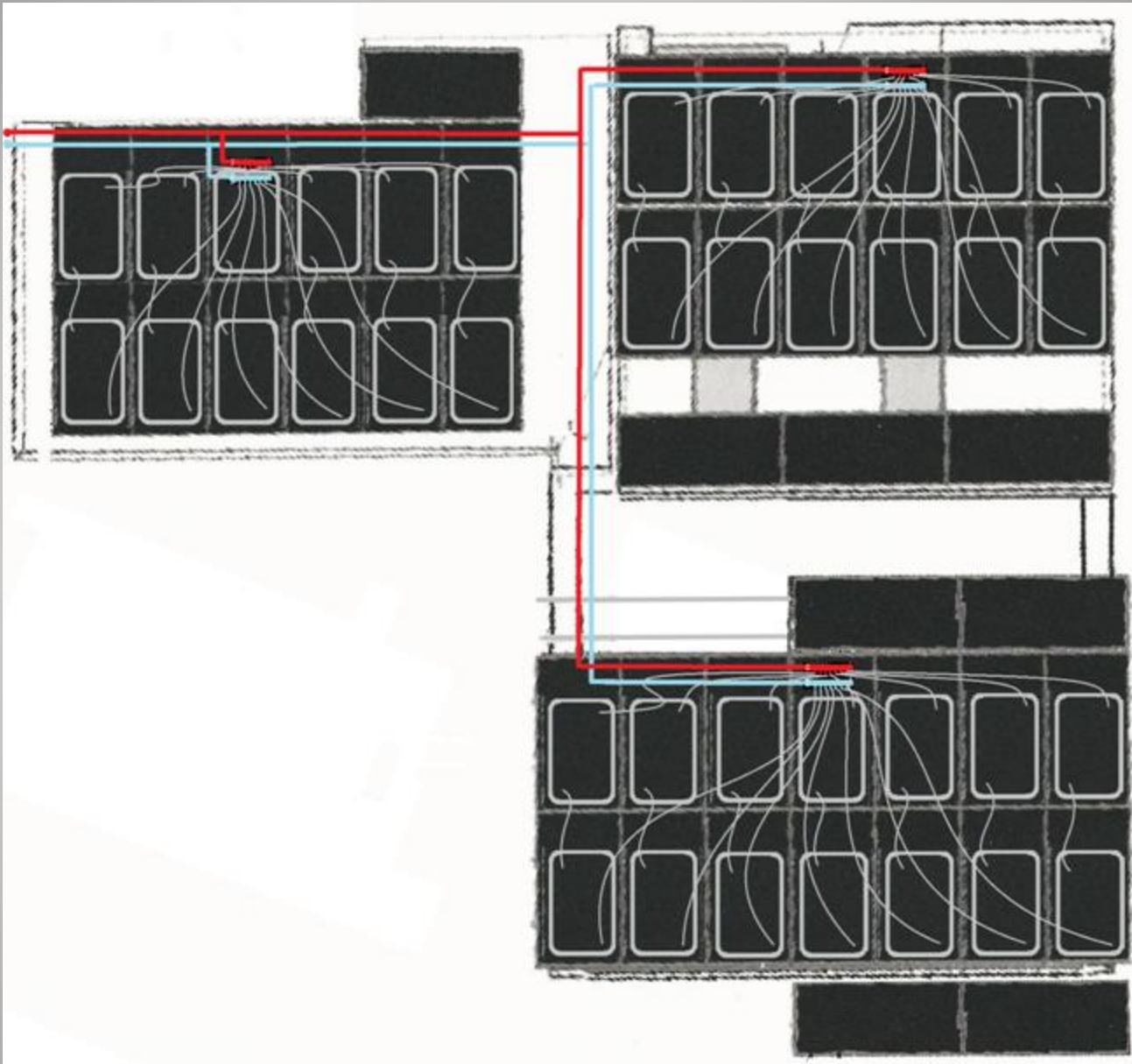
APPROXIMATELY 2,200 SF OF CONDITIONED SPACE ON MULTIPLE LEVELS
THREE SEPARATE SOLAR PANEL SUB-ARRAY STRUCTURAL DESIGNS



CONVENTIONAL PV PANEL

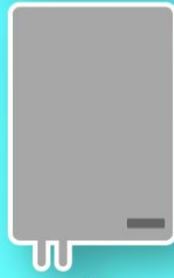


PV WITH SUNDRUM THERMAL PANEL



ENSER MORRIS SUNDRUM SOLAR ARRAY FLOW PATTERNS

OUT (kW)



IN (kW)



ELECTRICITY

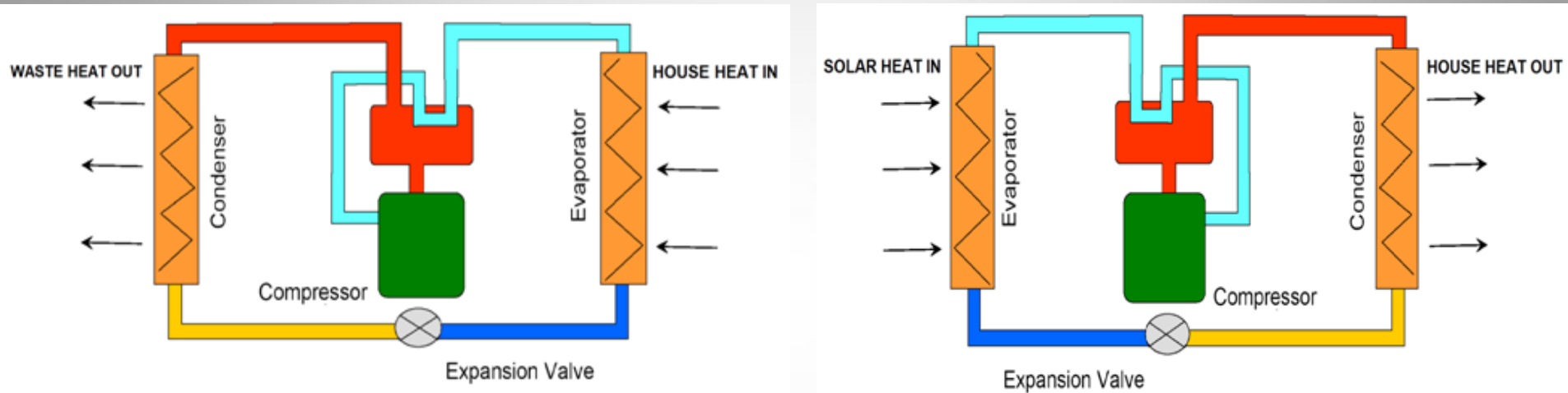
GAS / OIL

ELECTRICITY

'FREE' HEAT

HEAT PUMP IMPROVES EFFICIENCY USING 'FREE' ENERGY FROM SUN AND ENVIRONMENT VS CONVENTIONAL GAS, OIL, AND ELECTRIC HEATING SOURCES.

BASIC HEAT PUMP CONFIGURATION

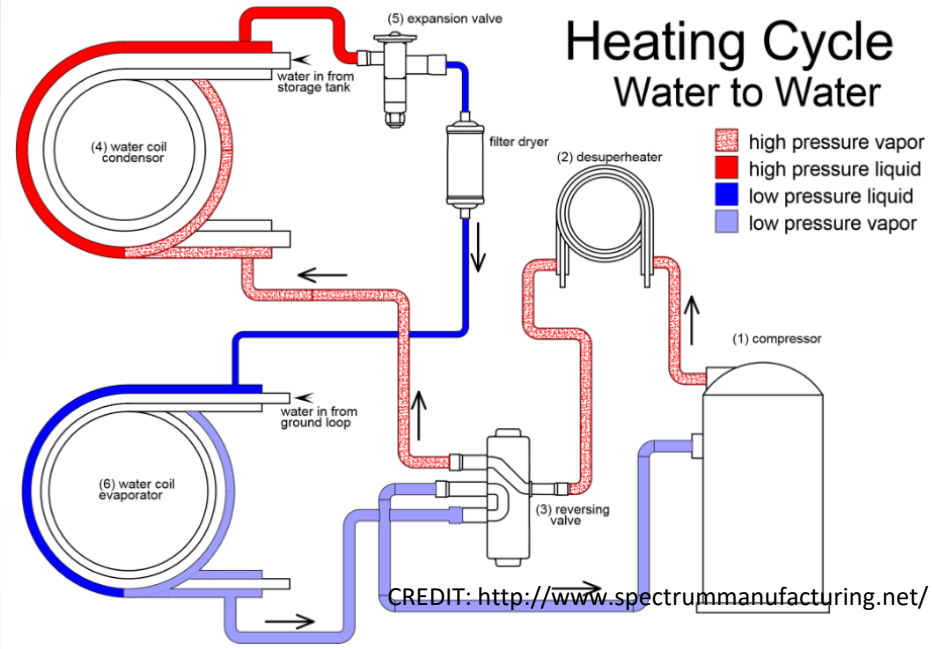
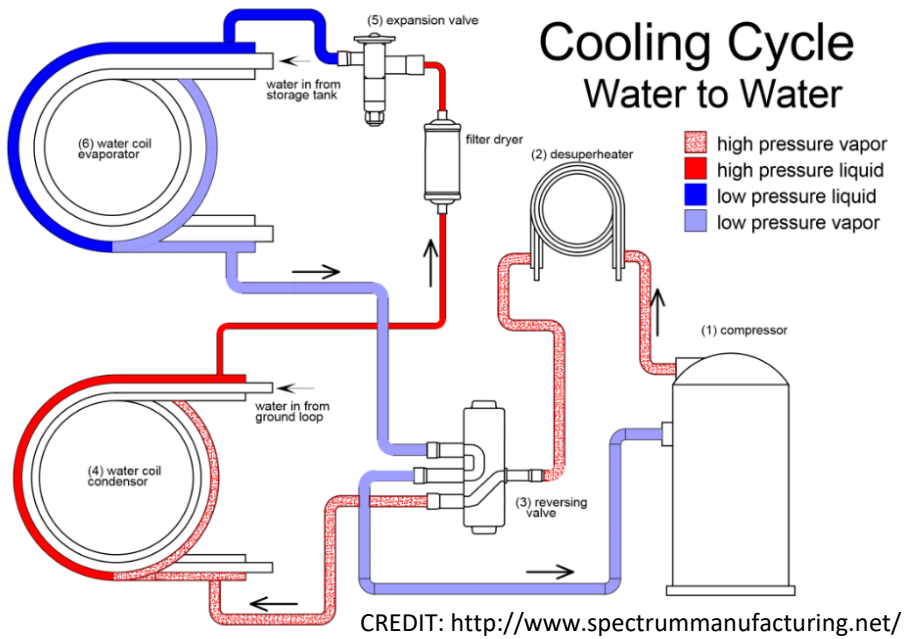


COOLING MODE`

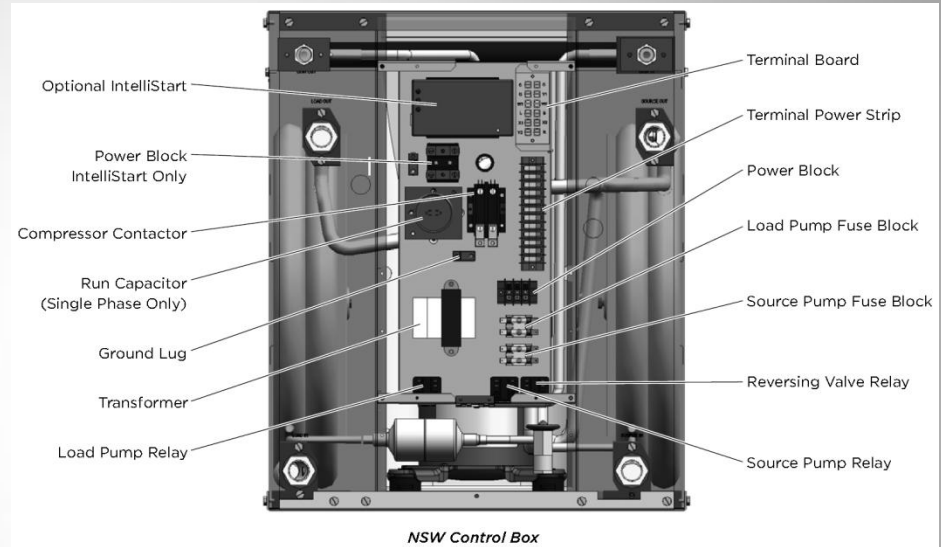
HEATING MODE

SOLAR SOURCE HEAT PUMP

THE HEAT PUMP HAS A REVERSING VALVE THAT CAN SWITCH THE DIRECTION OF THE REFRIGERANT FOR EITHER COOLING OR HEATING. IN THESE SYSTEMS, THE COILS SWITCH ROLES DEPENDING ON THE HEAT PUMP'S OPERATING MODE. WHEN HEATING, THE INDOOR EVAPORATOR COIL BECOMES A CONDENSING COIL, AND THE OUTSIDE COIL BECOMES THE EVAPORATOR COIL.



WATER-TO-WATER HEAT PUMP REFRIGERANT FLOW DIAGRAMS WITH DESUPERHEATER FOR DOMESTIC HOT WATER PREHEATING



SunDrum® Solar HarvestHP™
WaterFurnace ENVISION 040 MBTUH
SOLAR SOURCE WATER-TO-WATER HEAT PUMP
COP RANGE FROM 2 TO 5

SUNDRUM® SOLAR HARVESTHP™ SYSTEM ADVANTAGES:

- **SUPPLIES SOLAR ENERGY 24/7 ON DEMAND**
TRADITIONAL SOLAR DEPENDS ON LIMITED SOLAR CONDITIONS
ABLE TO EXTRACT STORED SOLAR ENERGY FROM ENVIRONMENT
COPs HIGHER WHEN DIRECT SOLAR BEAM RADIATION AVAILABLE
- **REDUCES STORAGE REQUIREMENTS**
NO NEED TO INCREASE STORAGE FOR RAINY DAY
- **PROVIDES DUAL MODE OPERATION - HEATING & COOLING**
DEPENDING ON APPLICATION
PROVIDES HEATING 24/7 ON SPLIT LOADS WITH NOCTURNAL COOLING
- **GENERATES ALL ENERGY REQUIREMENTS**
HYRID ELECTRICAL AND THERMAL

ENSER MORRIS HYBRID PV/T HP SYSTEM DESIGN

- **TOTAL 27KW HYBRID ARRAY**
 - 15.5 KW - 38 SUNDRUM THERMAL ARRAY TIED TO 040 HP**
 - 11.5 KW - 46 SUNPOWER PV PANEL ARRAY**
- **21,000 GALLONS/600 SF**
 - IN-GROUND POOL/THERMAL STORAGE**

- **ANNUAL ENERGY HARVESTING**
 - FREE ENERGY FRACTIONS – NOVEMBER 23, 2015 TO FEBRUARY 12, 2017**
 - 100% POOL HEATING**
 - >95% SPACE COOLING**
 - 86.1% SPACE HEATING**
 - 84.3% DOMESTIC HOT WATER**
 - 75.3% ELECTRICITY**

PEPCO INTERCONNECTION APPROVAL DATE: JANUARY 2, 2015



**HOME RESKINNED + NEW HIGH PERFORMANCE MARVIN WINDOWS & DOORS
OCTOBER/NOVEMBER 2017**

NOT TYPICAL - SINCE LOAD SHOULD BE REDUCED FIRST

- 1. ENERGY CONSERVATION**
- 2. WASTE ENERGY RECOVERY**
- 3. ENERGY EFFICIENCY**
- 4. PASSIVE SOLAR**
- 5. ACTIVE SOLAR**

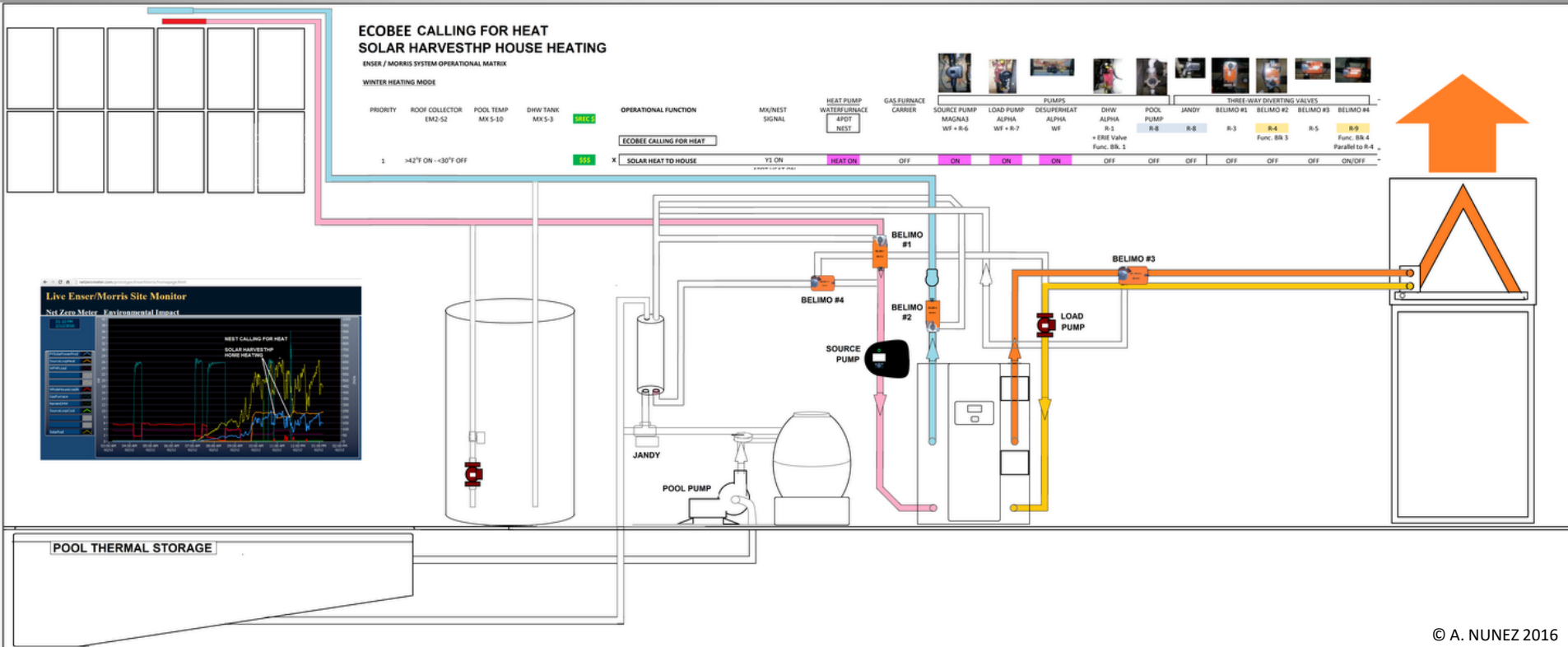
GOAL: NET ZERO ENERGY ANNUALLY?

WORK / MORRIS HYBRID SOLAR THERMAL SYSTEM

WORKING MODE

PUMP ID	PUMP CONTROL	PUMP TYPE	PUMP NAME	PUMP STATUS	PUMP FUNCTION	PUMP CONTROL	PUMP STATUS	PUMP TYPE	PUMP				PUMP					
									SOLE PUMP	SOLE PUMP	SOLE PUMP	SOLE PUMP	SOLE PUMP	SOLE PUMP	SOLE PUMP	SOLE PUMP		
PUMP CONTROL MODE 1																		
1	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
1	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
1	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
PUMP CONTROL MODE 2																		
1	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
PUMP CONTROL MODE 3																		
1	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON
2	ON	ON		ON	SOLE PUMP TO HEAT	SOLE PUMP	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON	ON

ENSER MORRIS HYBRID SOLAR THERMAL SYSTEM - MODE MATRIX



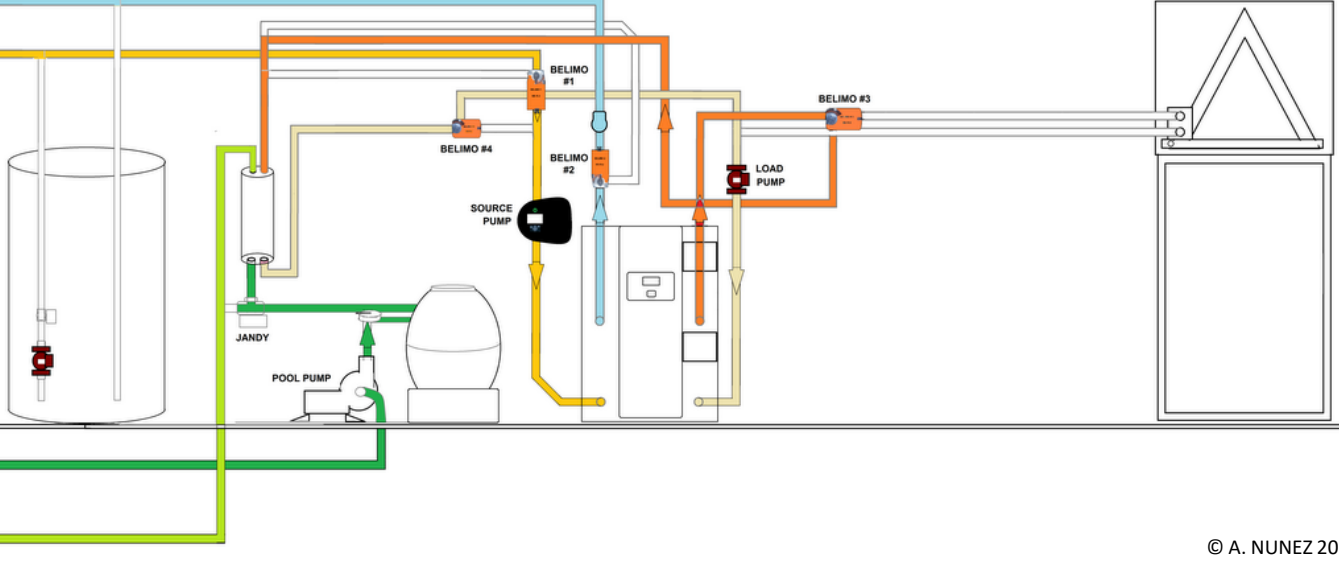
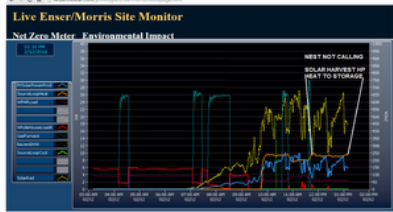
**WINTER
ECOBBEE CALLING FOR HEAT
HARVESTHP™ HEATING HOUSE FROM SUNDRUM® SOLAR ROOF ARRAY**

SOLAR HARVESTHP HEATING POOL STORAGE

ENSER / MORRIS SYSTEM OPERATIONAL MATRIX

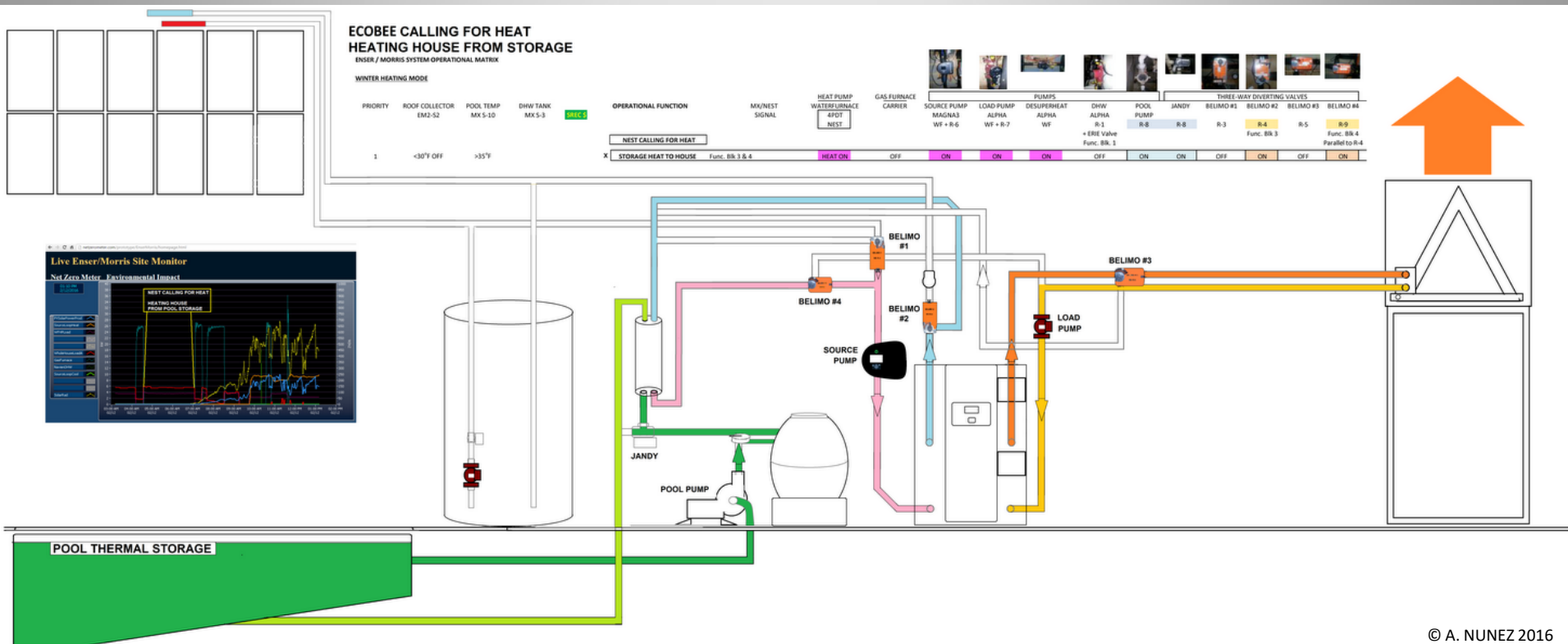
WINTER HEATING MODE

PRIORITY	ROOF COLLECTOR	POOL TEMP	DHW TANK	OPERATIONAL FUNCTION	MX/NEST SIGNAL
	EM2-S2	MX 5-10	MX 5-3		
> 90		>90		NEST NOT CALLING FOR COOLING	
				STORAGE HEAT TO NIGHT SKY 20:00 - 06:00 HRS	



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WINTER SUNDRUM® SOLAR HARVESTHP™ HEATING POOL STORAGE



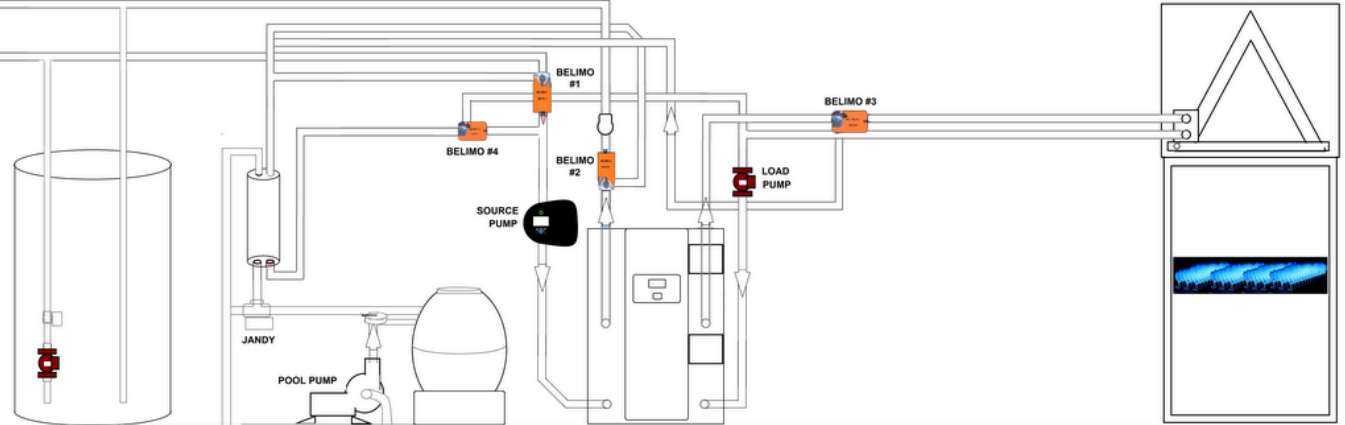
**WINTER
ECOBEE CALLING FOR HEAT
HEATING HOUSE FROM STORAGE VIA HARVESTHP™**

ECOBEE CALLING FOR HEAT HEATING HOUSE FROM AUXILIARY GAS FURNACE

ENSER / MORRIS SYSTEM OPERATIONAL MATRIX

WINTER HEATING MODE

PRIORITY	ROOF COLLECTOR	POOL TEMP	DHW TANK	OPERATIONAL FUNCTION	MV/NEST SIGNAL	HEAT PUMP WATER/FURNACE	GAS FURNACE CARRIER	SOURCE PUMP MAGNA3	LOAD PUMP ALPHA	DESUPERHEAT ALPHA	DHW ALPHA	POOL PUMP	JANDY	THREE-WAY DIVERTING VALVES				
	EM2-S2	MX 5-10	MX 5-3			WATER/FURNACE		WF + R-6	WF + R-7	WF	R-1 + ERIE Valve Func. BR. 1	R-8	R-8	R-3	BELIMO #1	BELIMO #2	BELIMO #3	BELIMO #4
1	<40°F	<35°F	HEAT	SECOND STAGE GAS HEATING FP TRIP / NEST <67°F	W AUX ON	OFF	ON	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF	OFF



POOL THERMAL STORAGE

© A. NUNEZ 2016

WINTER GAS FURNACE EMERGENCY HEATING

DIRECT POOL COOLING TO NIGHT SKY

ENSER / MORRIS SYSTEM OPERATIONAL MATRIX
SUMMER COOLING MODE

PRIORITY	ROOF COLLECTOR	POOL TEMP	DHW TANK	OPERATIONAL FUNCTION	MX/NEST SIGNAL
2	EM2-S2	MX 5-10	MX 5-3	NEST NOT CALLING FOR HEAT	OFF

OPERATIONAL FUNCTION
NEST NOT CALLING FOR HEAT
DIRECT POOL HEAT TO NIGHT SKY
20:00 - 06:00 HRS

HEAT PUMP
WATER/URNANCE
4PDT
NEST
OFF

GAS/LUBRANCE
CARRIER
OFF

SOURCE PUMP
MAGNA3
WF + R-6
ON

LOAD PUMP
ALPHA
WF + R-7
OFF

PUMPS
DESUPERHEAT
ALPHA
WF
OFF

DHW
ALPHA
R-1
+ EISE Valve
Func. BR. 1
OFF

POOL
PUMP
R-8
ON

JANDY
R-8
ON

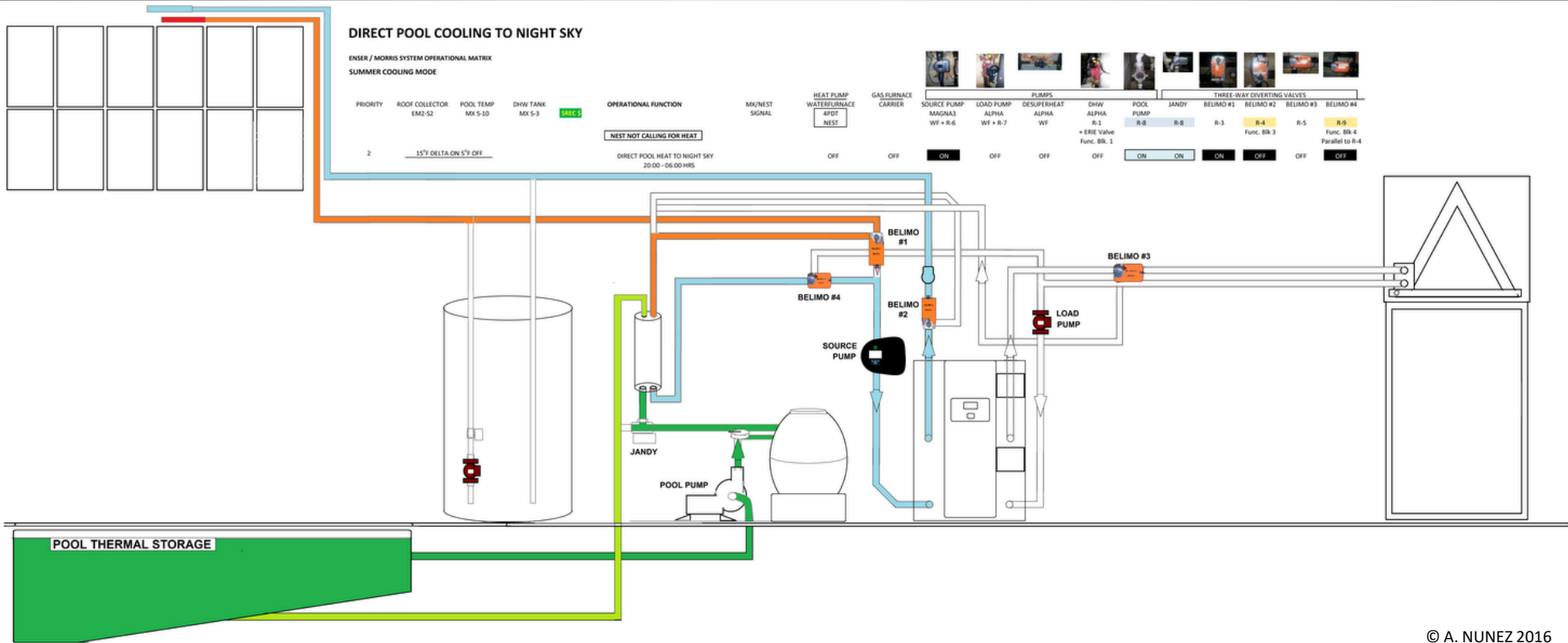
BELIMO #1
R-3
ON

BELIMO #2
R-4
OFF

BELIMO #3
R-5
OFF

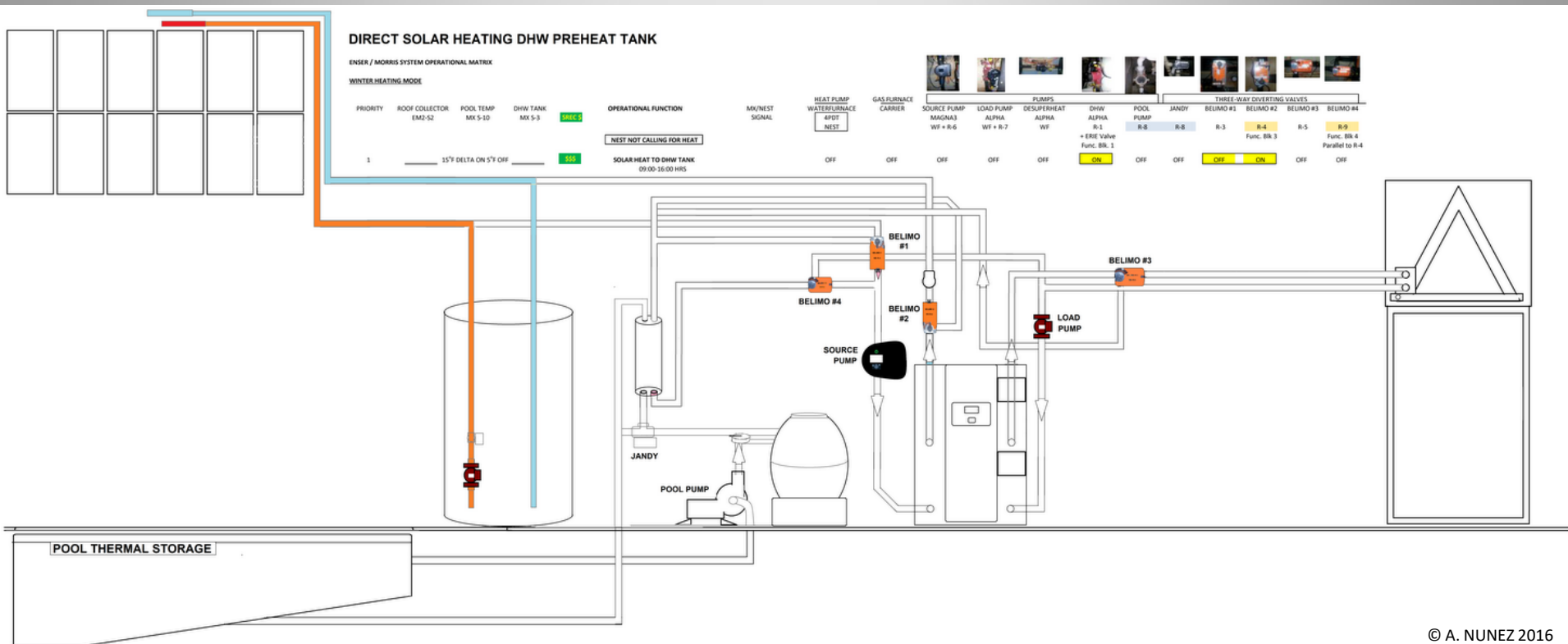
BELIMO #4
R-9
OFF

THREE-WAY DIVERTING VALVES
Func. BR. 3
Parallel to R-4



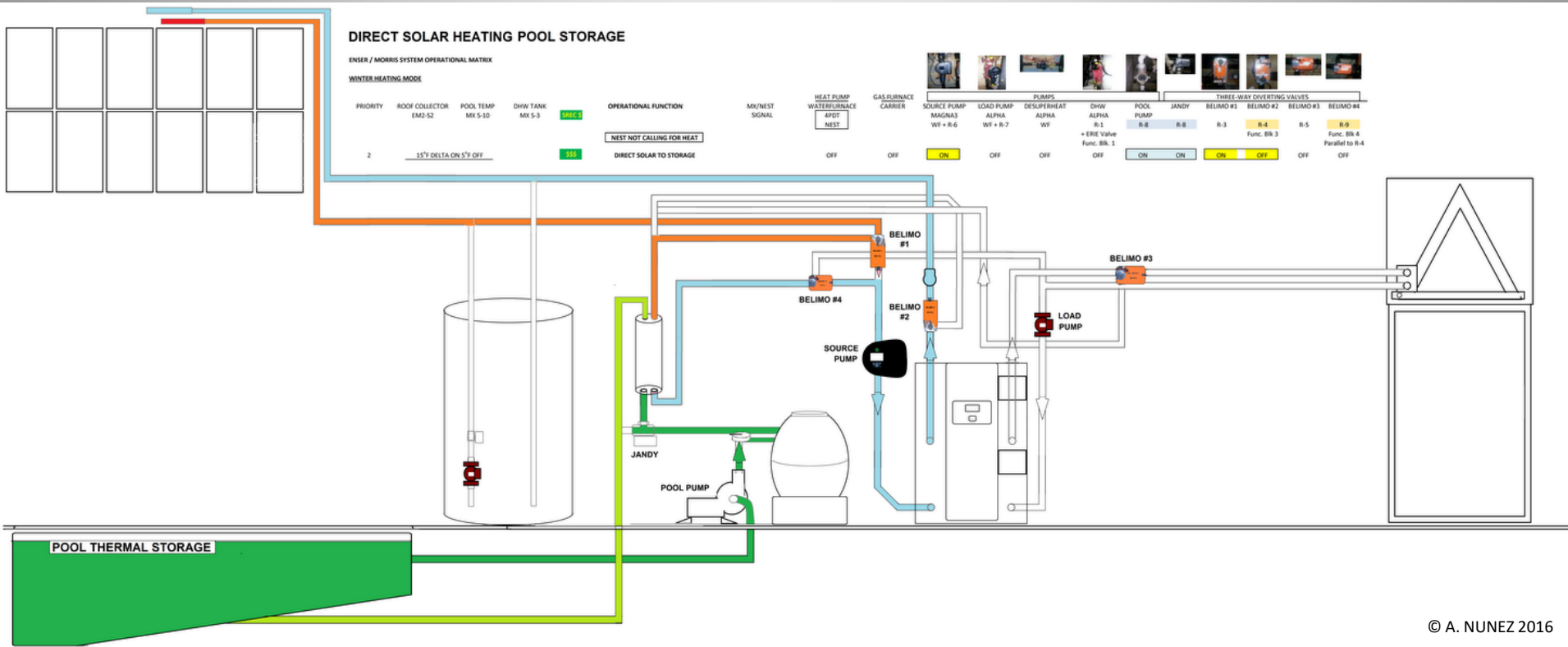
© A. NUNEZ 2016

SPRING / FALL DIRECT POOL COOLING TO NIGHT SKY



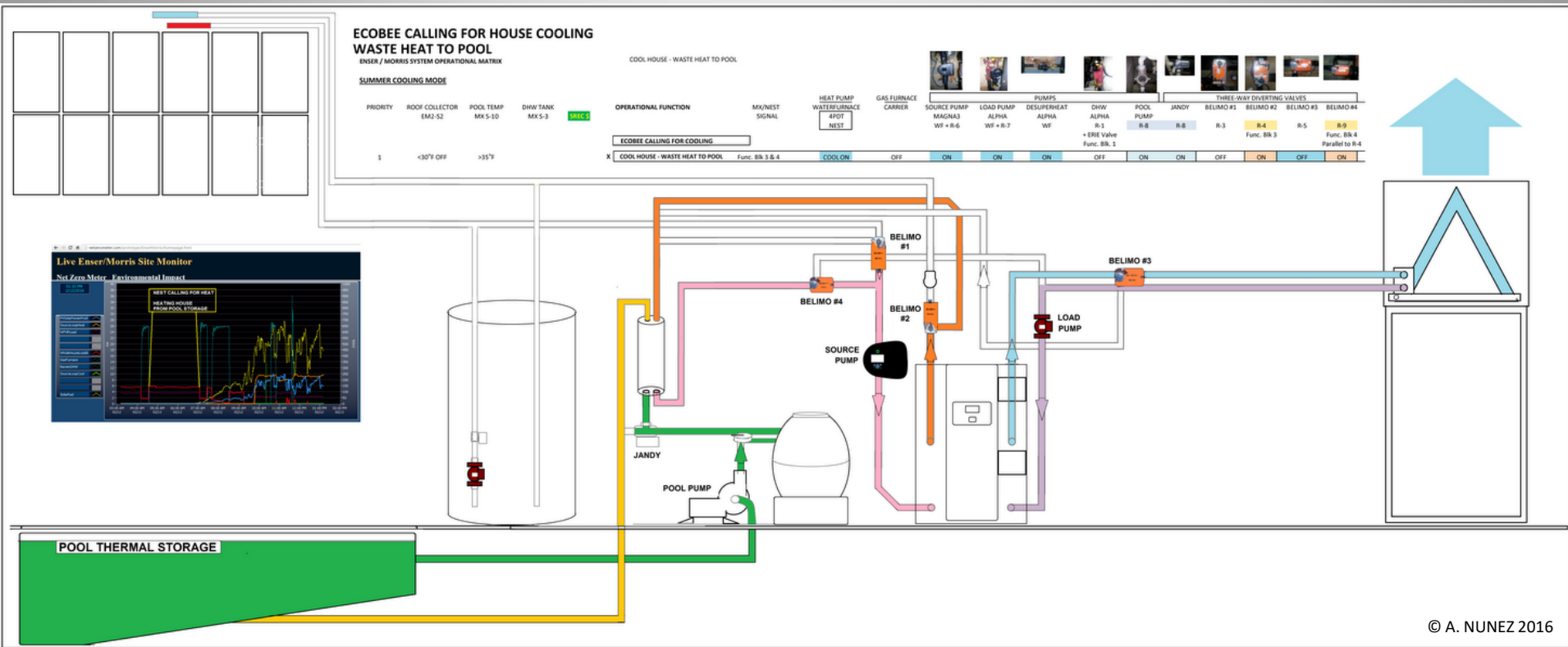
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SPRING/FALL/SUMMER DIRECT SOLAR HEATING DHW PREHEAT TANK

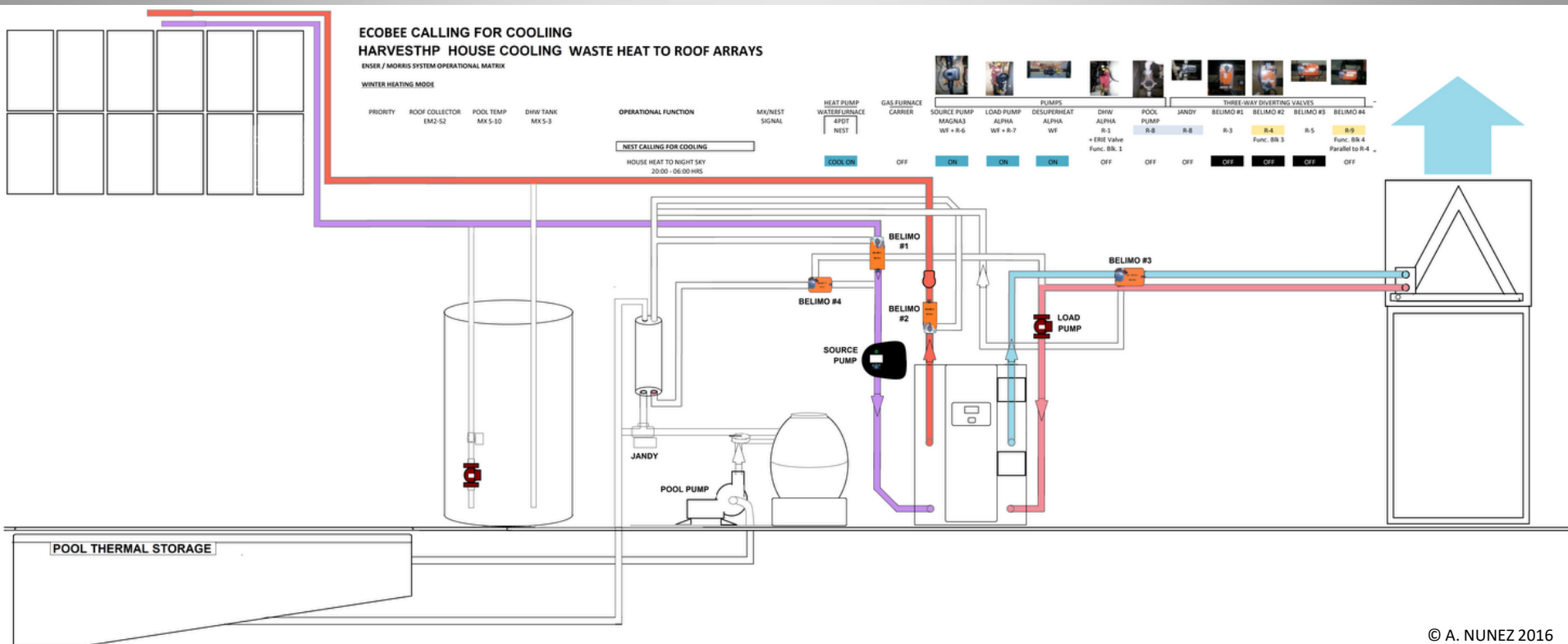


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SPRING/FALL/SUMMER DIRECT SOLAR HEATING POOL STORAGE

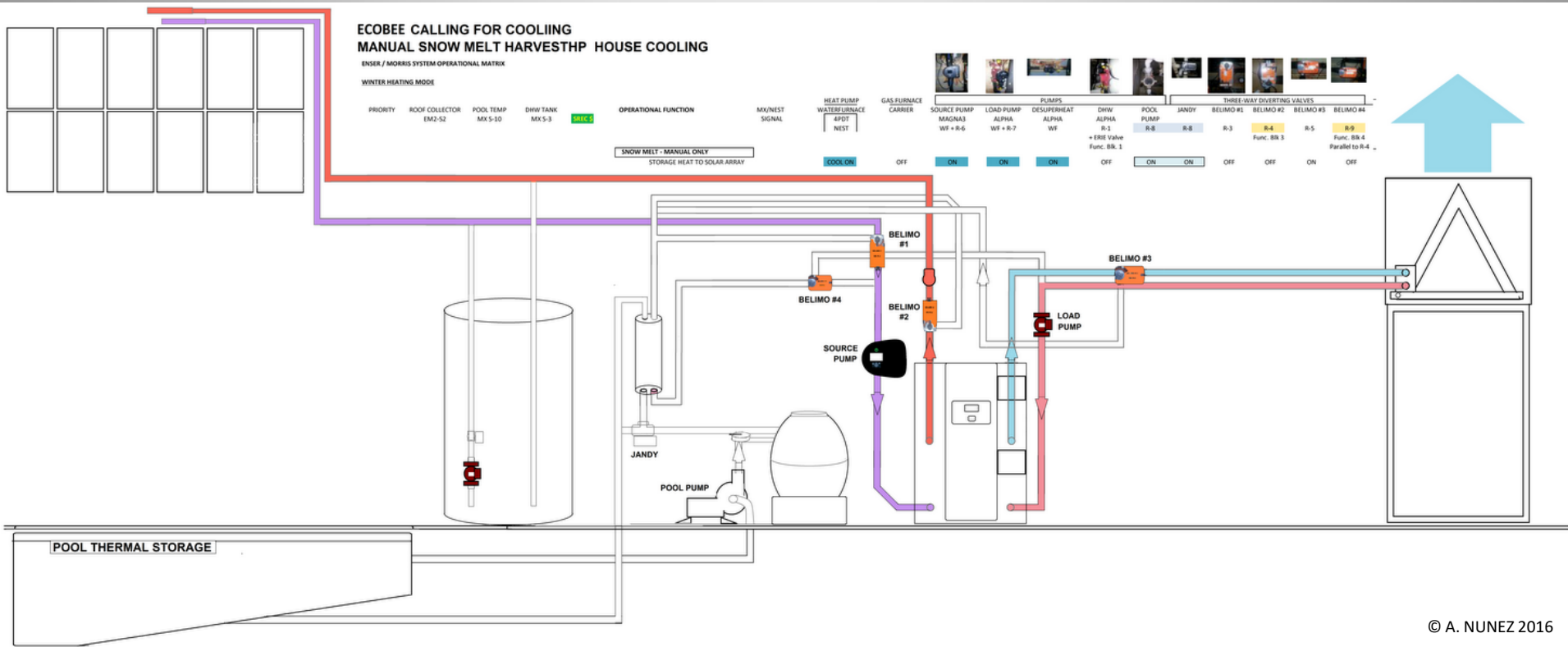


**SPRING/FALL/SUMMER
ECOBEE CALLING FOR HOUSE COOLING
WASTE HEAT TO POOL**



© A. NUNEZ 2016

**SPRING/FALL/SUMMER
ECOBBE CALLING FOR COOLING
HARVESTHP™ COOLING HOUSE REJECTING HEAT TO ROOF SUNDRUM® ARRAY**



**WINTER FORCED SNOW MELTING
MANUALLY SET ECOBEE TO COOLING
WITH WASTE HEAT TO SUNDRUM® SOLAR ROOF ARRAY**

TEMCO CONTROLS T3 BB DDC SYSTEM

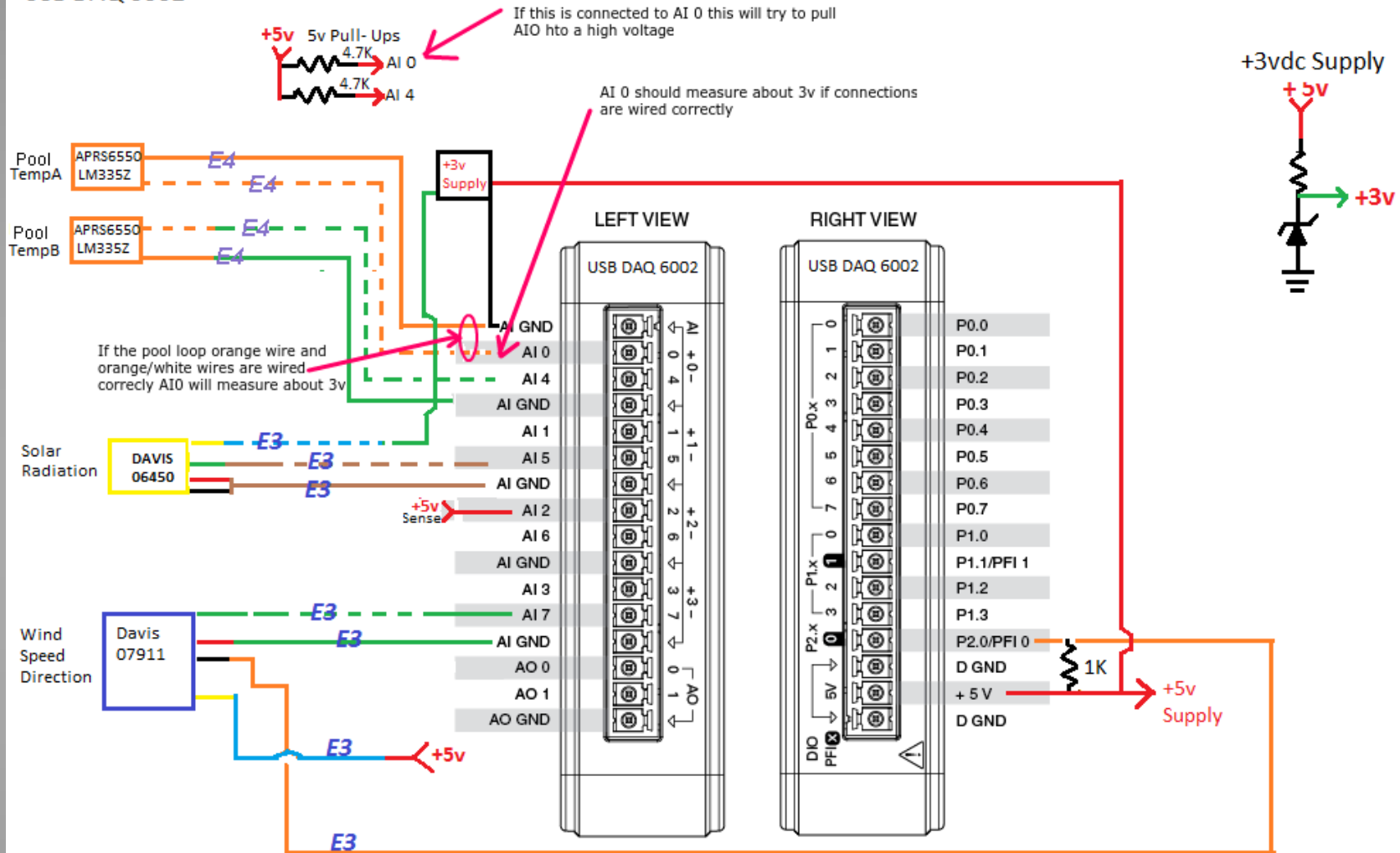
T3 BACnet PROGRAMMABLE CONTROLLER

- MODBUS
- BACnet
- CE
- LEED
- PROJECT HAYSTACK
- GitHub
- PROGRAMMED IN BASIC
- LOW COST (<\$500)
- COUNTRY OF ORIGIN: CHINA



T3-BB

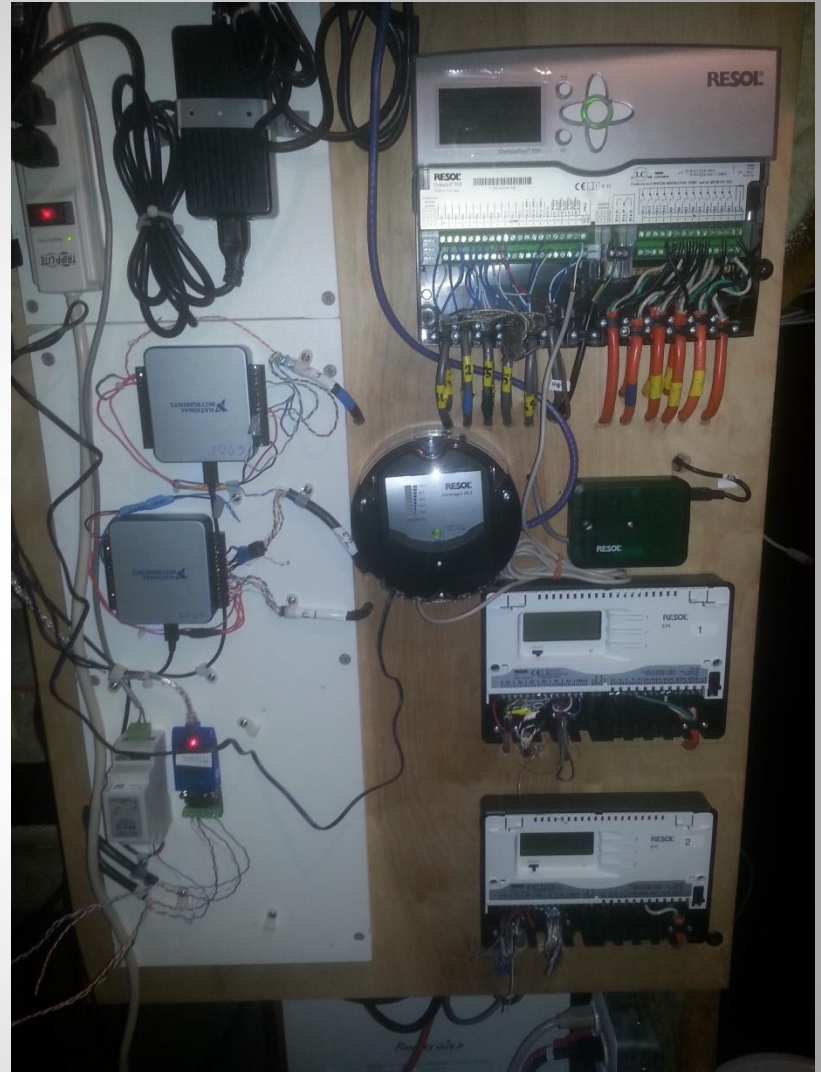
USB DAQ 6002



E3 = Ethernet Cable E3
E4 = Ethernet Cable E4

NET ZERO METER DAQ SYSTEM

ENSER MORRIS DAQ SYSTEM



**NET ZERO METER SOLAR MONITORING SYSTEM
RESOL SOLAR THERMAL CONTROL SYSTEM**



TEMCO T3 DDC SYSTEM CONTROLLER

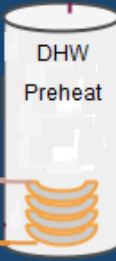
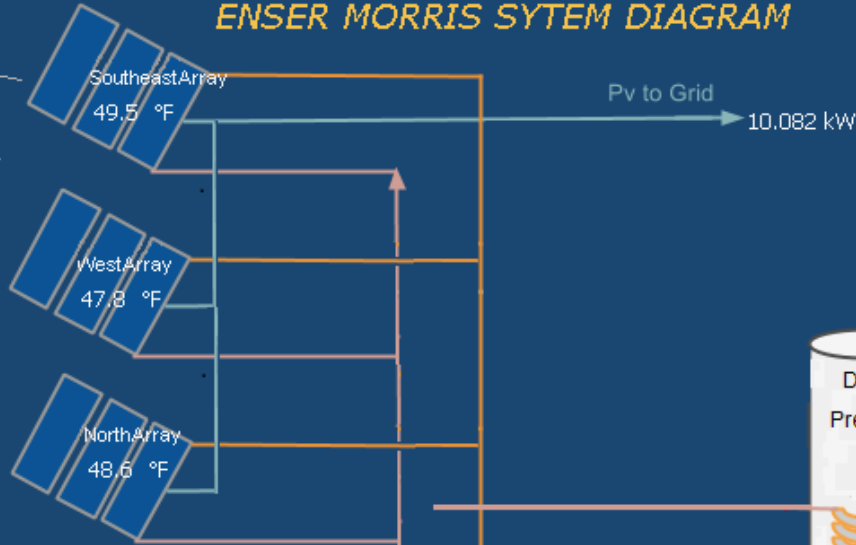


DAQ MONITORING SYSTEM

12:27 PM
3/24/2018

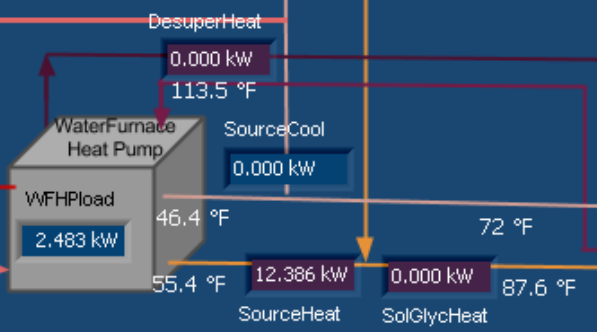
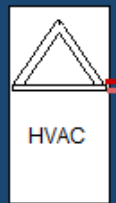
200 °F

ENSER MORRIS SYTEM DIAGRAM



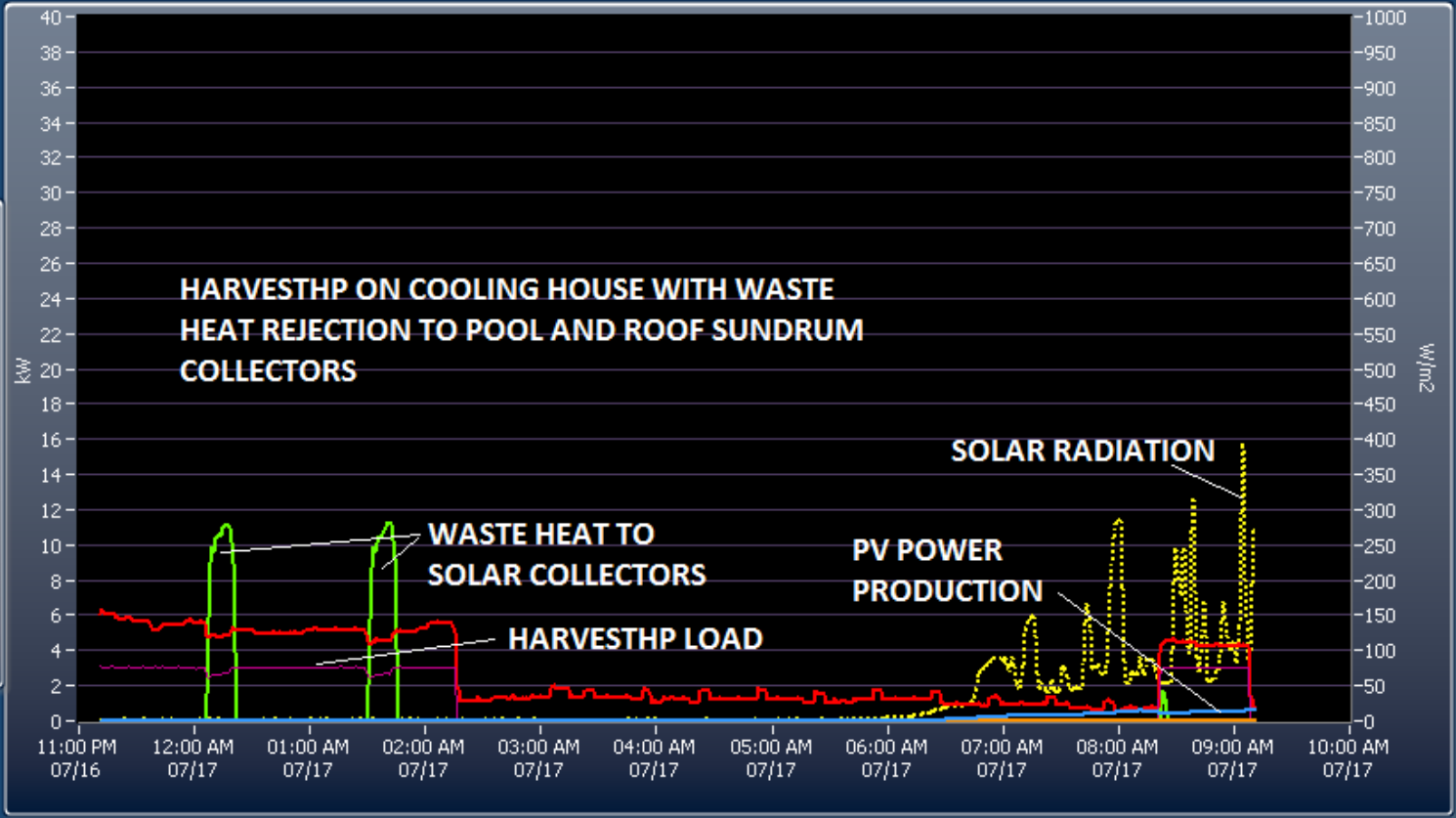
LoadLoopCool
0.000 kW

LoadLoopHeat
0.000 kW



09:10 AM
7/17/2016

- PVSolarPowerProd
- SourceLoopHeat
- WFHPLoad
- WholeHouseLoadA
- GasFurnace
- NavienDHW
- SourceLoopCool
- SolarRad

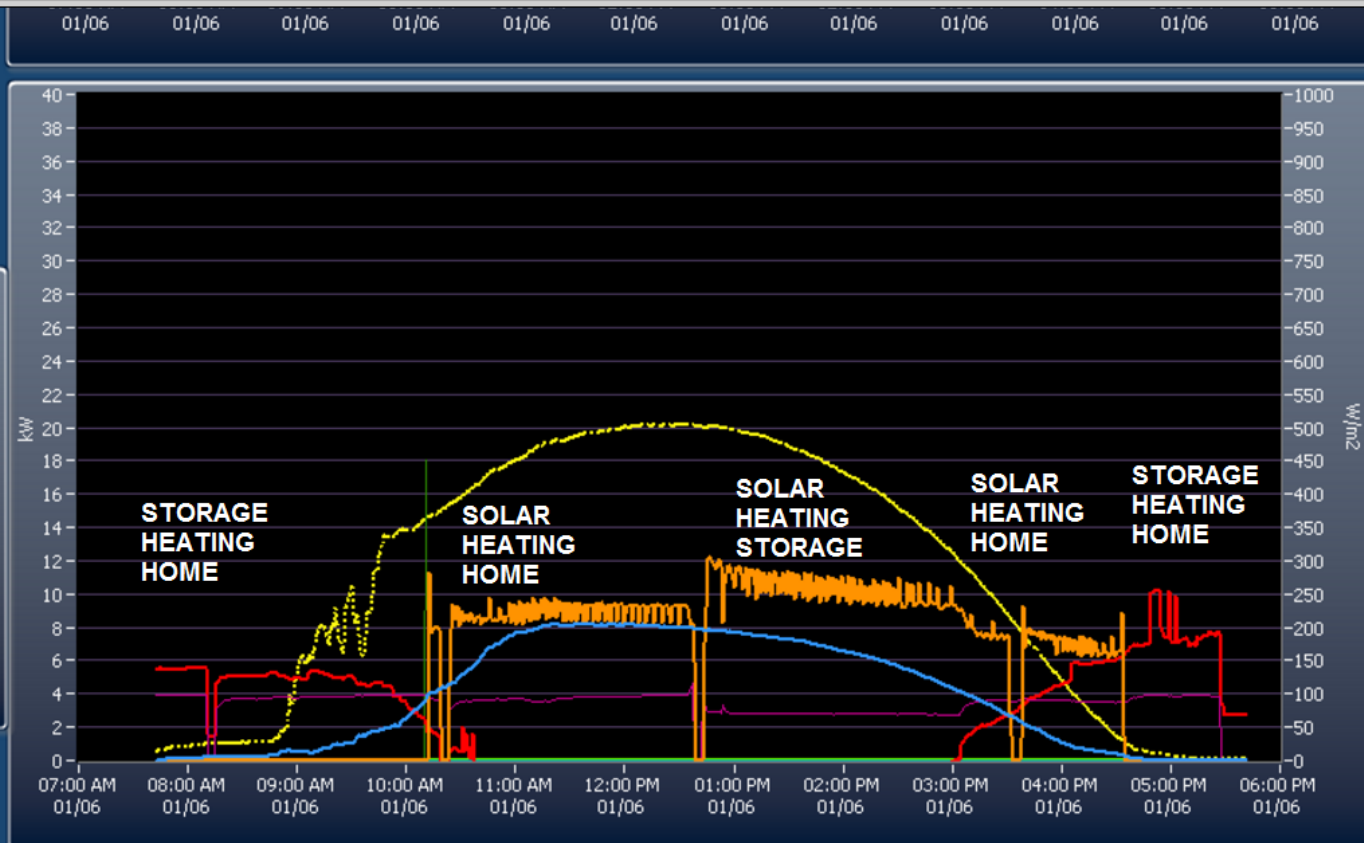


Live Enser/Morris Site Monitor

Net Zero Meter Environmental Impact

05:41 PM
1/6/2016

- PVSolarPowerProd
- SourceLoopHeat
- WFHPLoad
- WholeHouseLoadA
- GasFurnace
- NavienDHW
- SourceLoopCool
- SolarRad



09:10 AM
7/17/2016

Power Meters

PVSolarPowerProd

8533.1 kWh

0.569 kW

WFHPLoad

8879.1 kWh

0.006 kW

WholeHouseLoadA

10745.3 kWh

0.685 kW

Natural Gas Meters

GasFurnace

18823 ft3

kW

0 BTU/h

NavienDHW

4285 ft3

kW

0 BTU/h

BTU Meters

SourceLoop

16382.048 kWh

0.000 kW

861.973 kWh

0.000 kW

0 gpm

In

93.2 °F

Out

100.4 °F

LoadLoop

23350.105 kWh

0.000 kW

5587.658 kWh

0.000 kW

0 gpm

52.6 °F

39.3 °F

DesuperHeatLoop

3230.385 kWh

0.000 kW

133.7 °F

135.3 °F

DHWLoop

130.707 kWh

-0.012 kW

84.4 °F

84.9 °F

In

Out

Pumps

WFSourcePump

0 psi

0.000 gpm

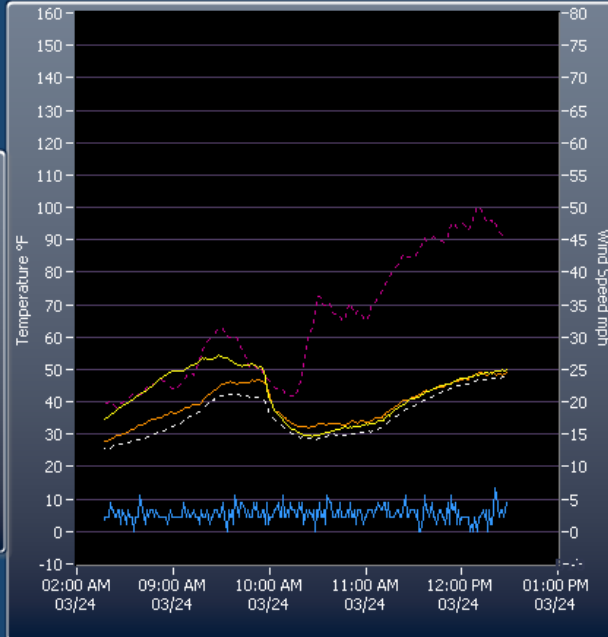
0 kW

0 ft

12:28 PM
3/24/2018

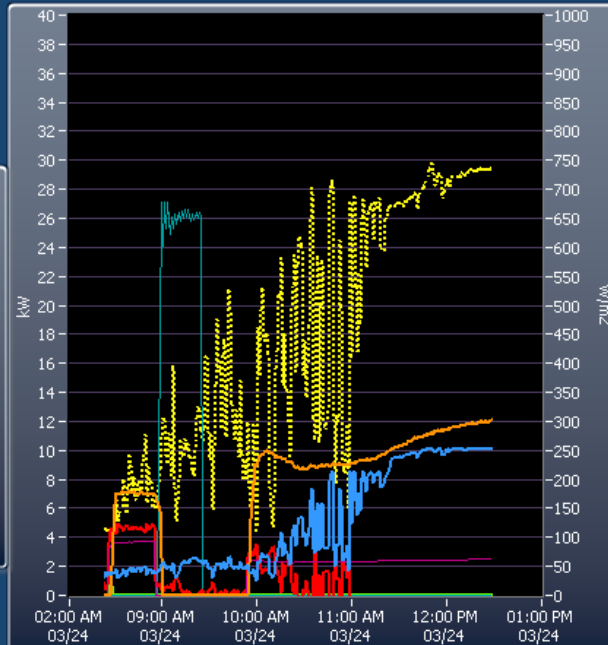
Rolling Composite Plot

- Outdoor
- SouthEast
- West
- NorthCtrl
- North
-
-
-
-
-
- Wind



12:28 PM
3/24/2018

- PVSolarPowerProd
- SourceLoopHeat
- WFHPLoad
-
- WholeHouseLoadA
- GasFurnace
- NavienDHW
- SourceLoopCool
-
- SolarRad

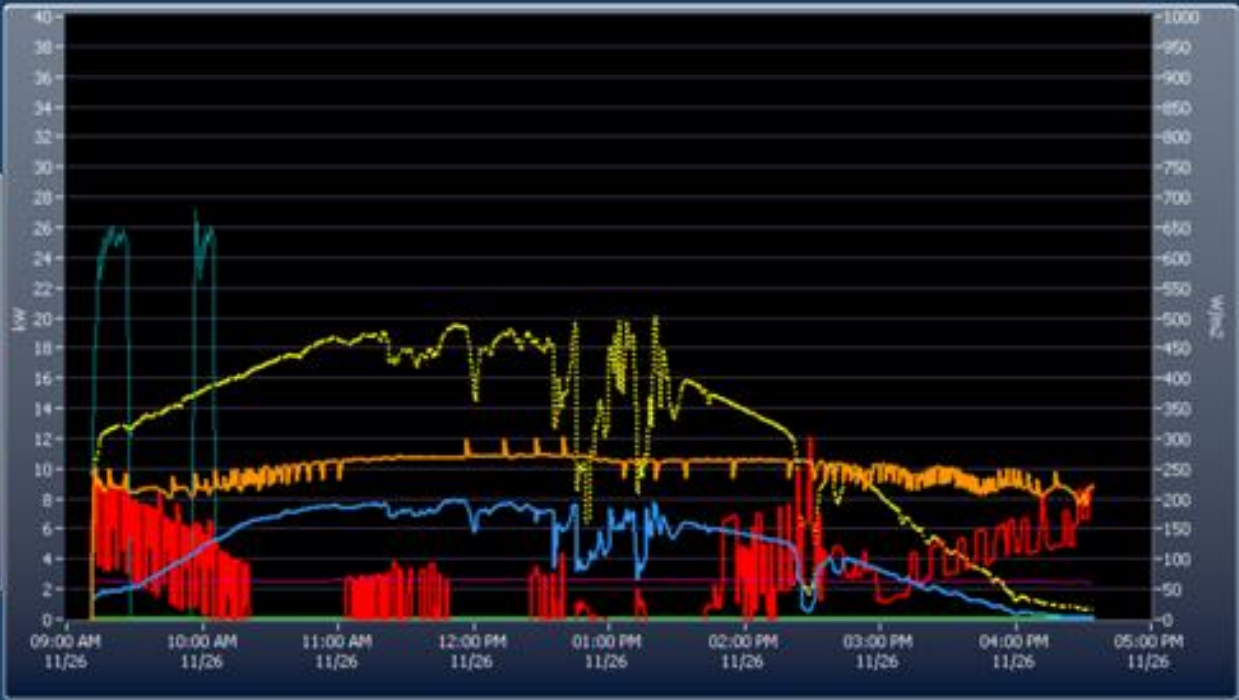


Live Enser/Morris Site Monitor

Net Zero Meter Environmental Impact

04:34 PM
11/26/2015

- PrSolarPowerProd
- SourceLoopHeat
- WFHLoad
- WholeHouseLoadA
- NavierDHW
- GasFurnace
- SourceLoopCool
- SolarRad

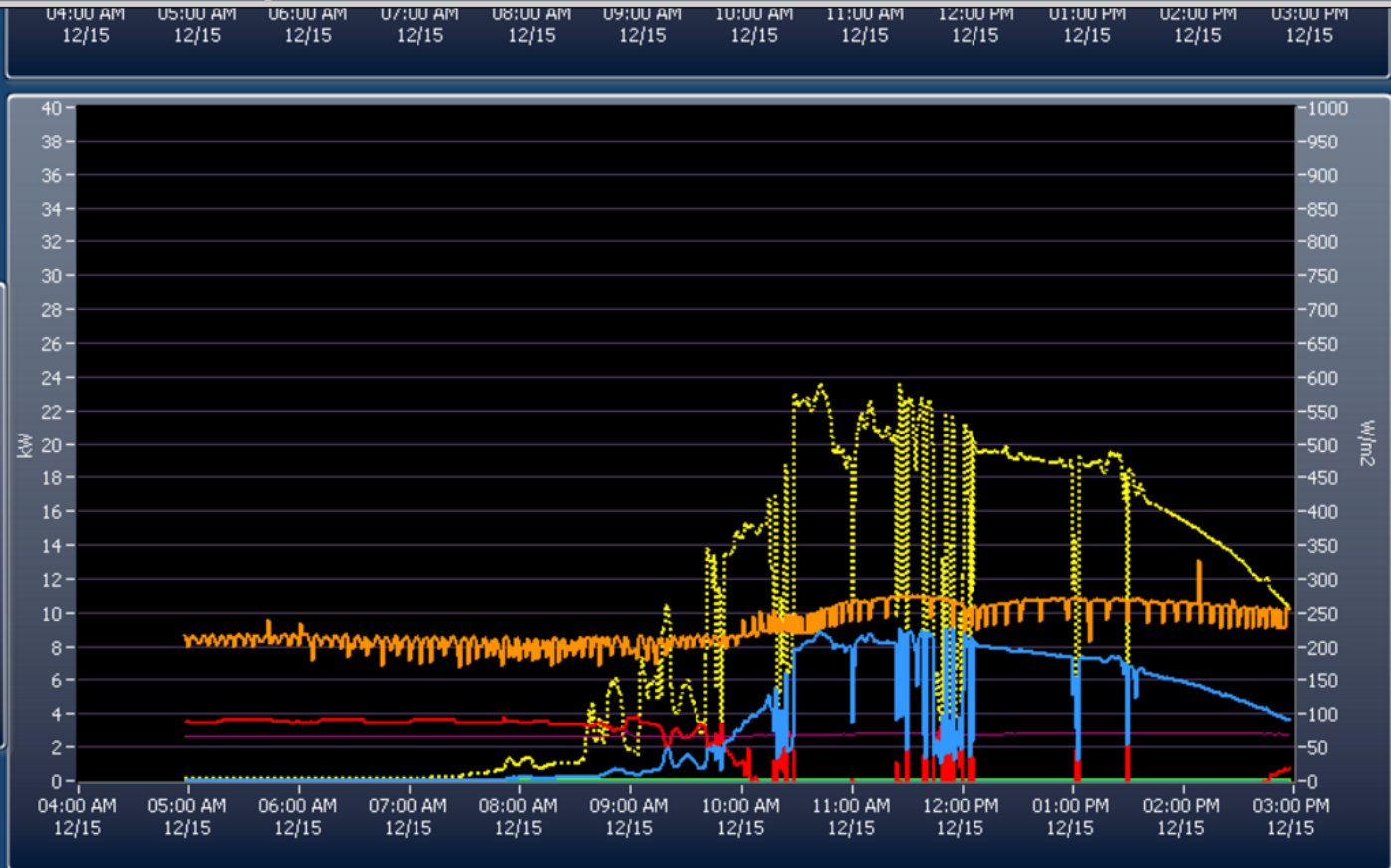


Live Enser/Morris Site Monitor

Net Zero Meter Environmental Impact

02:57 PM
12/15/2015

- PVSolarPowerProd
- SourceLoopHeat
- WFHPLoad
- WholeHouseLoadA
- NavienDHW
- GasFurnace
- SourceLoopCool
- SolarRad



Live Enser/Morris Site Monitor

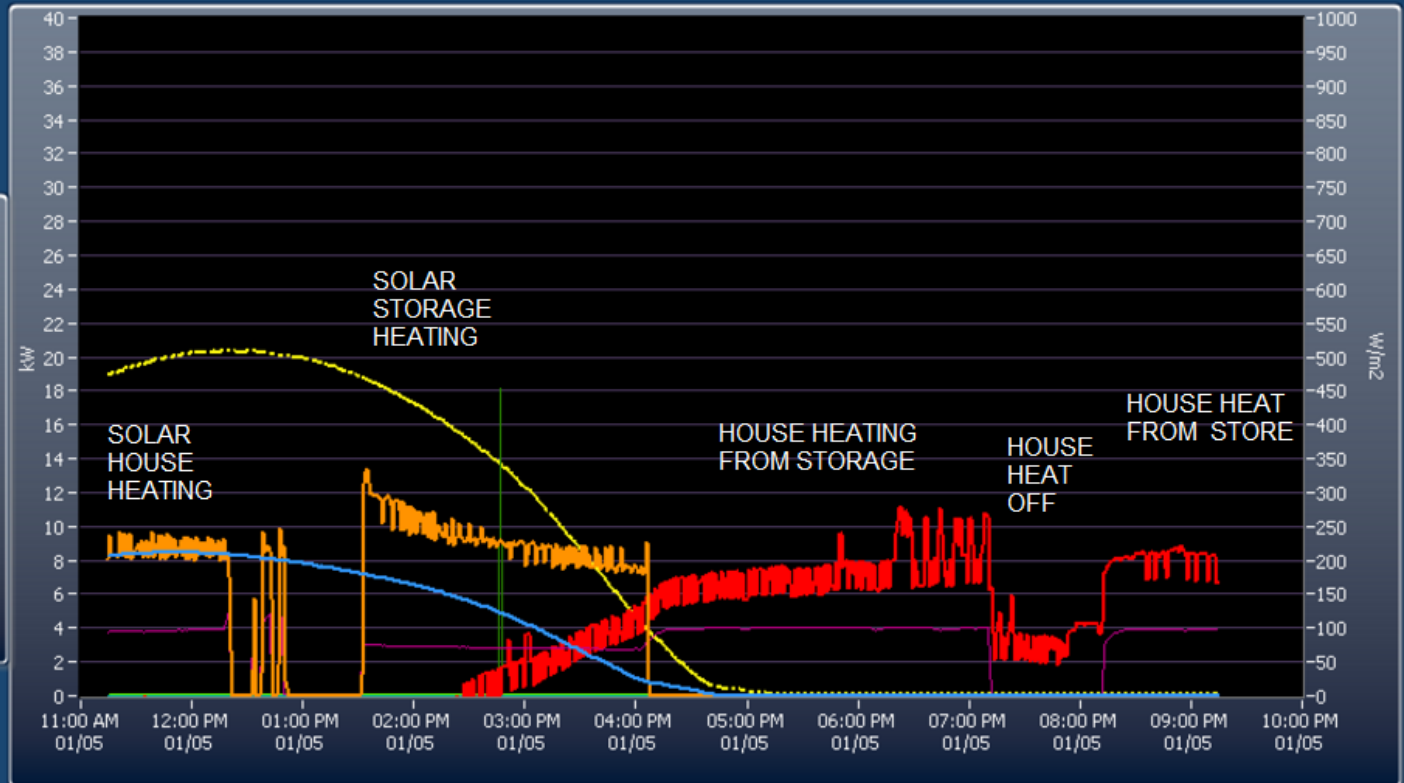
Net Zero Meter Environmental Impact

Wind



09:14 PM
1/5/2016

- PVSolarPowerProd
- SourceLoopHeat
- WFHPLoad
- WholeHouseLoadA
- GasFurnace
- NavienDHW
- SourceLoopCool
- SolarRad





INDIVIDUAL PANEL POWER MONITORING
RAPID SHUTDOWN FEATURE FOR 2017 NEC COMPLIANCE



**TWO SUNPOWER/SMA-AMERICA 5 KW PV INVERTERS
WITH EMERGENCY POWER OUTLET ON RIGHT**



HEAT PUMP TECHNOLOGY IS AVAILABLE IN VIRTUALLY ANY SIZE DESIRED.

SUNDRUM® SOLAR HARVEST HP™ HEAT PUMP SYSTEMS CAN BE INSTALLED (RETROFITTED) ON EXISTING OR NEW ROOFTOP PHOTOVOLTAIC PROJECTS:

- HOTELS
- HOSPITALS
- AQUA CULTRUE FARMS
- GREENHOUSES
- BARRACKS
- NURSING HOMES
- DORMATORIES
- COMMERCIAL LAUNDRIES
- BREWERIES
- REASTAURANTS
- PREHEAT PROCESS WATER
- PREHEAT BOILER-FEED H₂O
- TEXTILE INDUSTRY WASHING
- FOOD PROCESSING



ALBERT NUNEZ 202.270.5000 albert.nunez@capitalsungroup.com

POINTS OF CONTACT:

HYBRID PV/THERMAL SOLAR SYSTEM DESIGNER & INSTALLATION CONTRACTOR:

CAPITAL SUN GROUP, Ltd.

CABIN JOHN, MD 20818

CARLO LA PORTA 301-520-0298 capital.sun@verizon.net

LEAD SYSTEM DESIGNER: ALBERT NUNEZ - 202-270-5000
albert.nunez@capitalsungroup.com

SOLAR THERMAL SYSTEM DESIGN ENGINEERING:

SUNDRUM SOLAR LLC

HUDSON, MA 01749

MICHAEL INTRIERI, ENGINEERING DIRECTOR – 978-257-2981
mintrieri@sundrumsolar.com

STRUCTURAL ENGINEERING PE:

WOLFMAN & ASSOCIATES, P.C.

SILVER SPRING, MD 20910

RONALD F. WOLFMAN, PE - 301-587-0260
rwolfman1@verizon.net

ELECTRICAL CONTRACTOR:

ECHO ELECTRIC COMPANY

KENSINGTON, MD 20895

BRUCE BARNES, MASTER ELECTRICIAN – 301-949-8051
bruce@echoelectric.net

PLUMBING CONTRACTOR:

FIRST CHOICE PLUMBING & HEATING , LLC

BELTSVILLE, MD 20705

PERCY JACKSON, MASTER PLUMBER 301-792-1122

SOLAR CONTROLS:

TEMCO T3 BB SYSTEM DEVELOPER & LOGIC PROGRAMMER

WASHINGTON, DC

NELSON MORRIS - 202.487.4355

nelson@nelsonmorris.com

DATA ACQUISITION:

NET ZERO METER

HUDSON, MA 01749

GEORGE JALBERT 978-697-5227
george.jalbert@netzerometer.com

ROOFER OF RECORD:

CENTRAL ROOFING & SIDING CO.

ROCKVILLE, MD 20852

ERIC KIBLER 301-881-2424

ARLINGTON CAREER CENTER

STUDENT CONSTRUCTION TEAM

ARLINGTON, VA

Margaret Chung, Principal - 703-228-5730

margaret.chung@apsva.us

SYSTEM COMPONENT DETAILS:

- 46 SunPower photovoltaic panels – model SPR-X21-250-BLK (250Wp)
- Tigo Optimizers for panels level monitoring and rapid shutdown capability
- 2 SunPower - SMA-America Sunny Boy SB500TL-US String Inverters
- 42 SunDrum[®] Solar thermal panels - Model SDM100-30 (480Wp)
- SunDrum[®] Solar HarvestHP[™] (WaterFurnace) Envision Model: NSW-040
 - 4-ton Reversible Water-to-Water Heat Pump with Desuperheater and Intelistart
- Grundfos Magna3 Smart Pump on Solar Glycol Loop
- Grundfos Stainless Steel Alpha Pump on Desuperheating Loop
- Grundfos Cast Iron Alpha Pumps on Load and Direct Solar DHW Preheat Loops
- Pentair IntelliFlo Variable Speed Pool Pump with Digital Time Clock | 3HP Max
- Four Belimo Three-way Motorized Diverting Valves
- Hayward Goldline- Jandy Three-way Pool Water Diverting Valve
- 80 Gallon Dual Heat Exchanger Kingspan Stainless Steel Solar Storage Tank
- K3N Spirec Stainless Steel Heat Exchanger (Pool Water/Glycol Loop)
- Magic Aire 4-ton Water-to-Air Chilled Water Coil
- EcoBee3 Smart Thermostat with Remote Sensor
- Temco T3 Big Brother (BB) Direct Digital Control (DDC) System
- 1 Resol DeltSOL MX Solar Controller with 2 Expansion Modules (EM) & Data Logger (DL3)
- Solar-Cell Sunblanket[™] (Double Layer in Winter) with Winter Cover Over Top
- Net Energy Meter Data Acquisition System
 - 3 WattNode Revenue Grade Watt Meters
 - 4 Istec Revenue Grade Btu Meters
 - 1 Temco 1" Flow Meter
 - 1 Davis Weather Station
 - 2 Natural Gas Meters

COMMISSIONING MILESTONES

04/01/2015 DC GIS OBLIQUE ANALYST DCOCTO SANBORN AERIAL
NEW ROOF INSTALLED, NO SOLAR

09/07/2015 TIGO MONITORING COMMISSIONING

09/21/2015 DCRA FINAL INSPECTION

10/28/2015 DAQ SITE DELIVERY

11/23/2015 DAQ SYSTEM COMMISSIONED

12/04/2015 SUNPOWER MONITORING SYSTEM COMMISSIONED

01/02/2016 PEPCO INTERCONNECTION APPROVAL