Solar Combi-systems: Active Solar Space Heating plus DHW How to Do It

Fred Milder, CEO
Claudia Pavel, Director of Sales and Marketing

SOLARLOGIC
Solar Heating Simplified

Solar Combi-systems:
Active Solar Space Heating plus DHW
How to Do It

PART 1: THE FOUNDATION

Bristol's Prime Directive and Six Principles
SolarLogic's Philosophy
Combi-system Design and Control Overview

PART 2: DETAILS AND EXAMPLES

Following the Prime Directive and Six Principles

PART 3: NOW YOU DO IT

Design a solar thermal combi-system

PART 4: BATTLING STICKER SHOCK

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Bristol's Stickney's

PRIME DIRECTIVE

Bristol Stickney
Chief Technical Officer
SolarLogic

"It must feel like an upgrade."

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Bristol's Six Principles of Good Solar Thermal Design

(roughly in order of their importance)

1. **Reliability**
2. **Effectiveness**
3. **Compatibility**
4. **Elegance**
5. **Serviceability**
6. **Efficiency**

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Bristol's Six Principles of Solar Thermal Systems

RELIABILITY

If it doesn't work all the time, nothing else matters.

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EFFECTIVENESS

Measured by the comfort of the user

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COMPATIBILITY

With the rest of the building industry

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ELEGANCE

Simple is better.

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SERVICEABILITY

When service is required, it's easy, efficient and inexpensive.

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EFFICIENCY

Optimal use of solar energy is important, but its relative importance is up to the client.

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After 40 Years, why is the Solar Thermal Industry not mainstream?

We're not following the prime directive and the six principles

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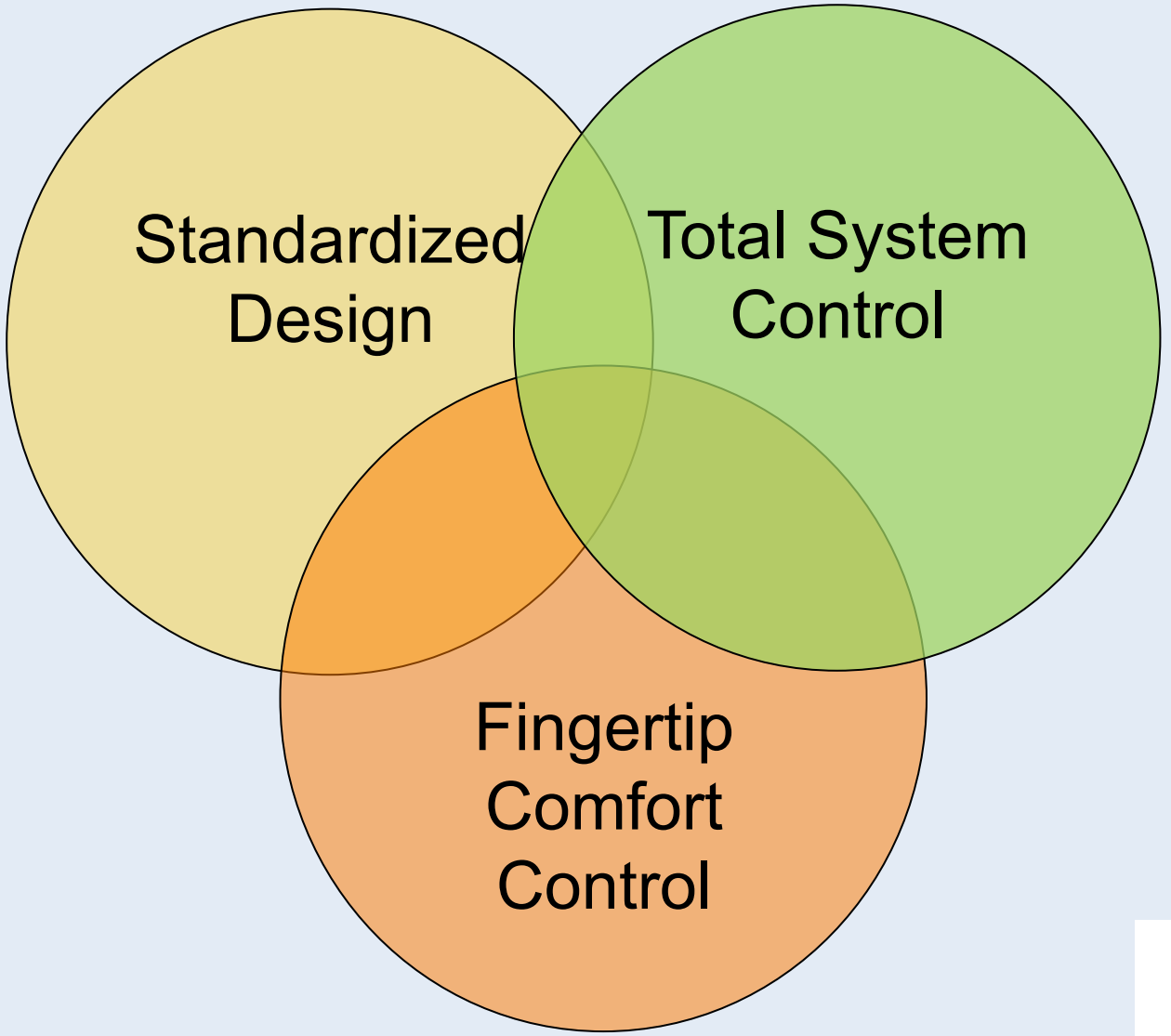
The SolarLogic Approach



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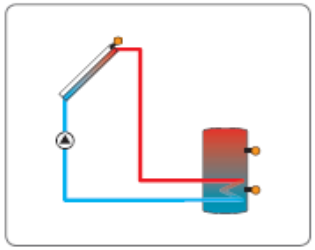
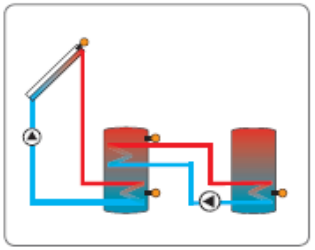
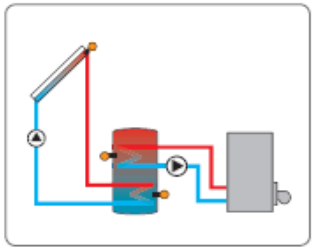
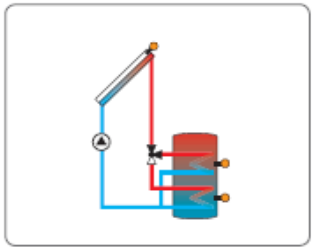
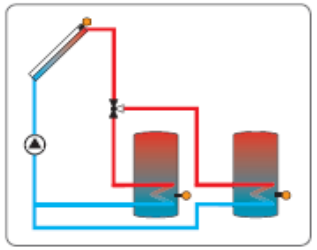
The Solar Design Dilemma

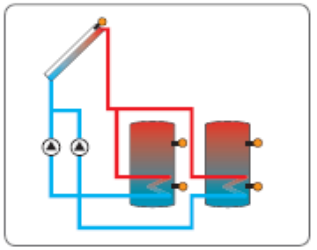

Solar system with 1 tank

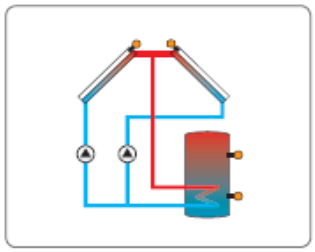

Solar system with 1 tank and heat exchange controller

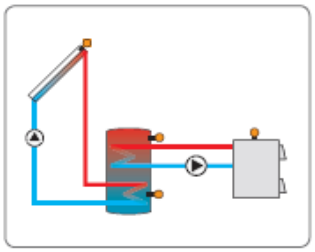

Solar system with 1 tank and thermostatic backup heating

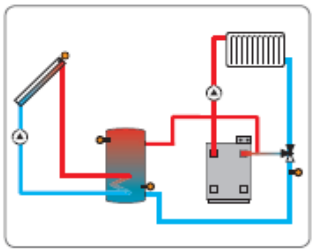

Solar system with tank loading in layers

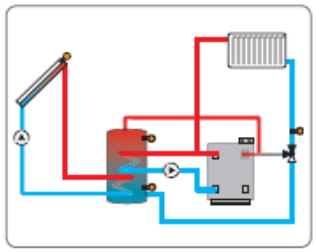

Solar system with 2 tanks, valve logic

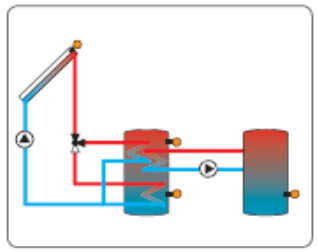

Solar system with 2 tanks, pump logic

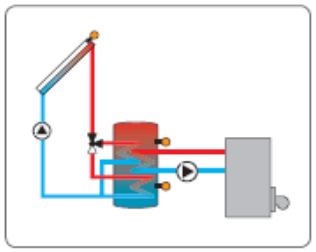

Solar system with east-/west collectors and 1 tank

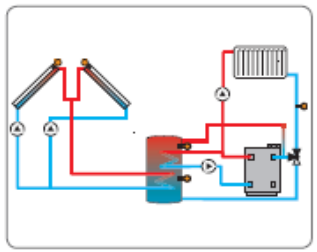

Solar system with 1 tank and solid fuel boiler

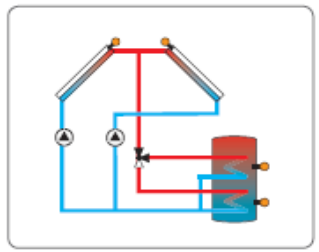

Solar system with 1 tank and heating circuit return preheating

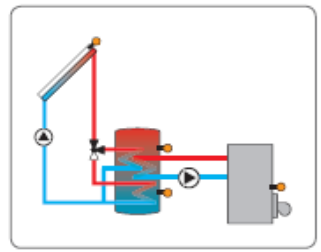

Solar system with 1 tank, heating circuit-return preheating and thermostatic backup heating

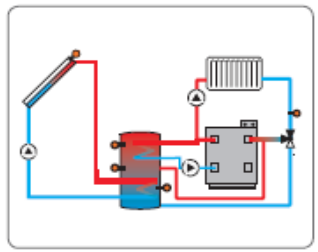

Solar system with tank loading in layers and heat exchange controller

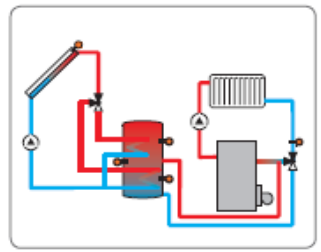

Solar system with tank loading in layers and thermostatic back-up heating

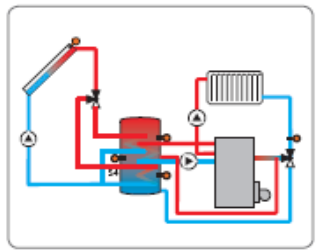

Solar system with east-/west collectors, heating circuit return preheating and thermostatic backup heating


Solar system with east-/west collectors and tank loading in layers


Solar system with tank loading in layers and solid fuel boiler


Solar system with 1 tank, heating circuit return preheating and thermostatic backup heating


Solar system with multi-layer tank and heating circuit return preheating


Solar system with multi-layer tank and heating circuit return preheating and thermostatic backup heating

Plenty of Choices from Suppliers

There are more things the same between individual solar thermal heating jobs than there are things different.

Until we focus on common plumbing design and control principles, we will be stuck where we are.

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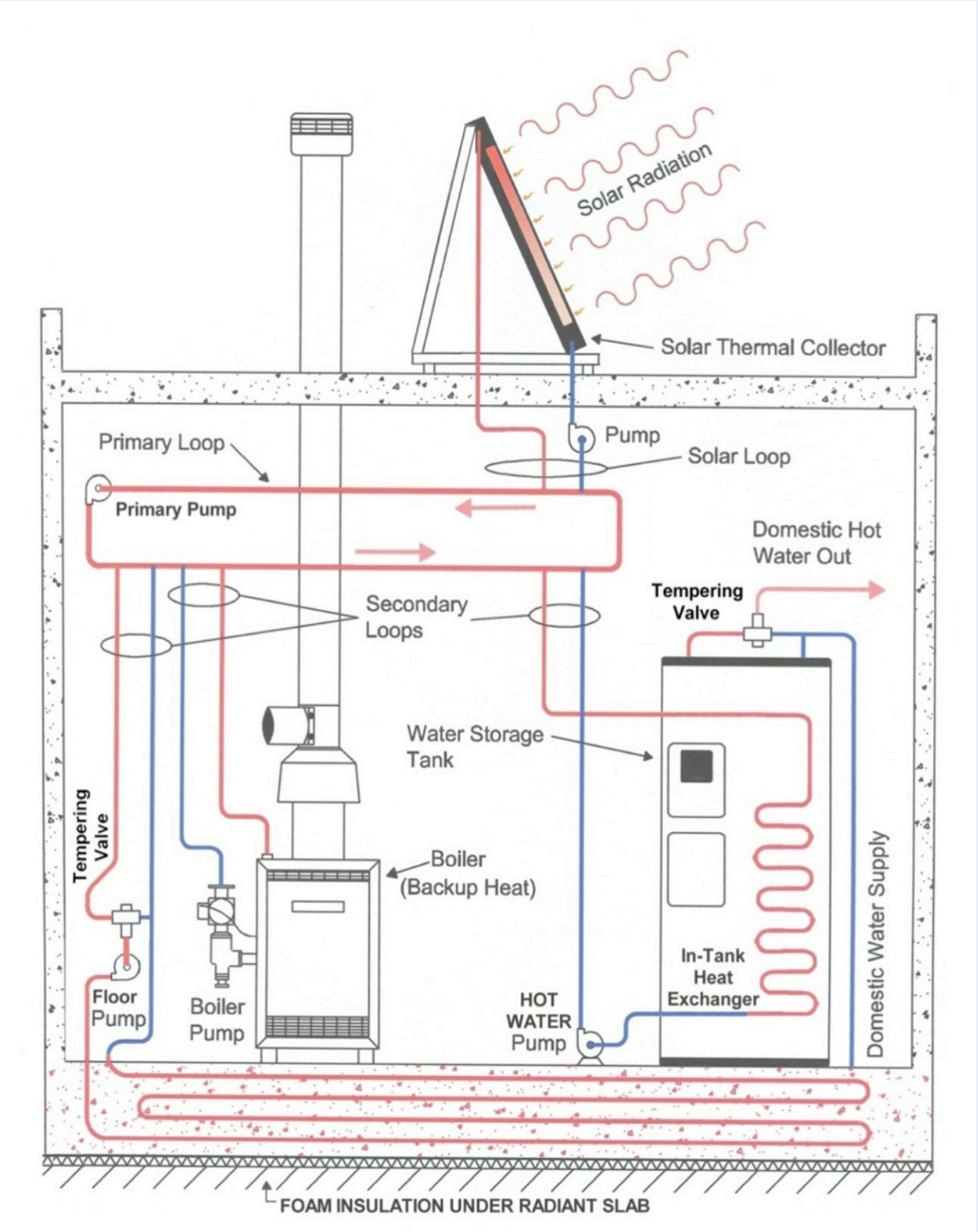
Primary Loop "Flow Center" Approach

Example: Glycol Direct

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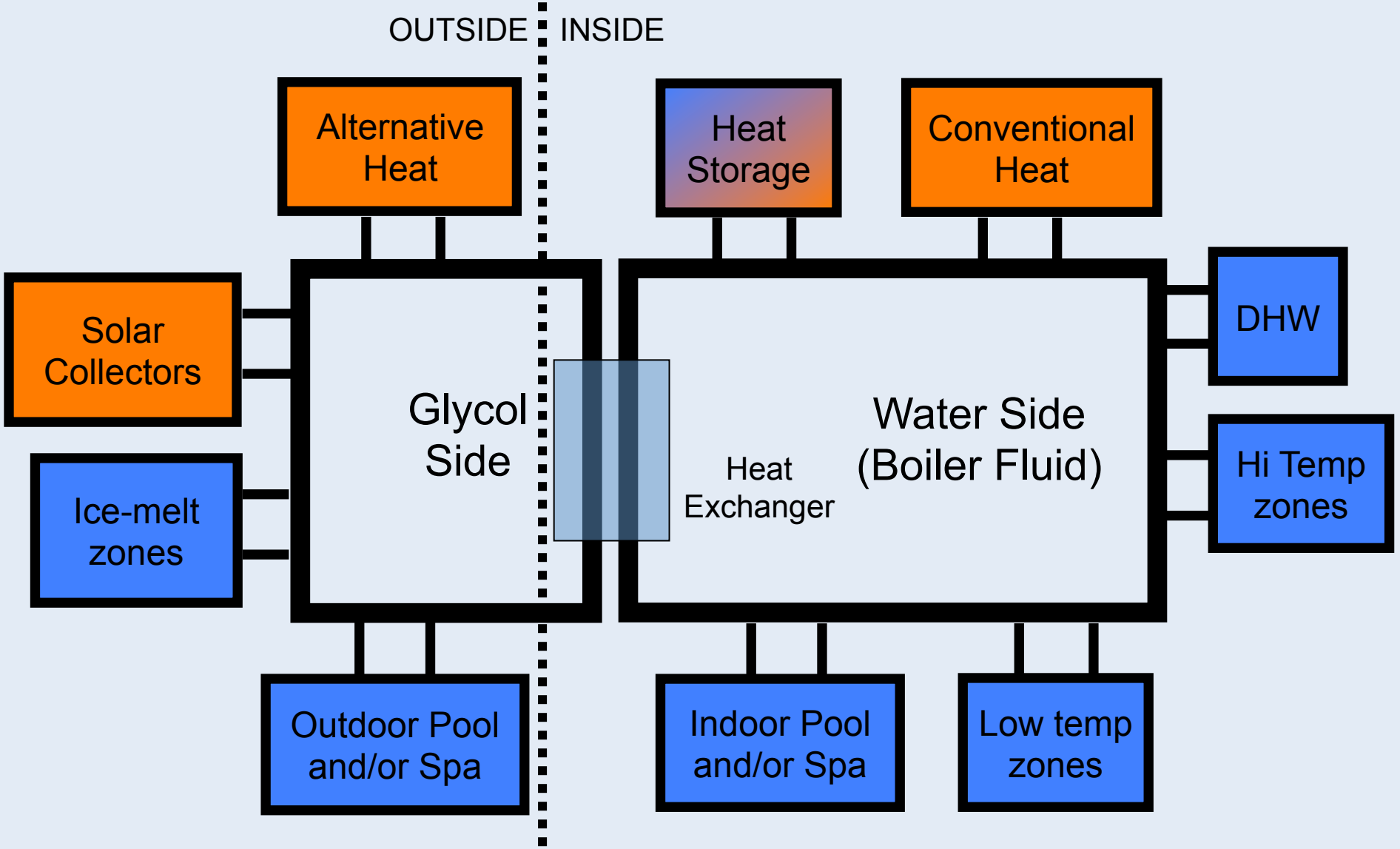
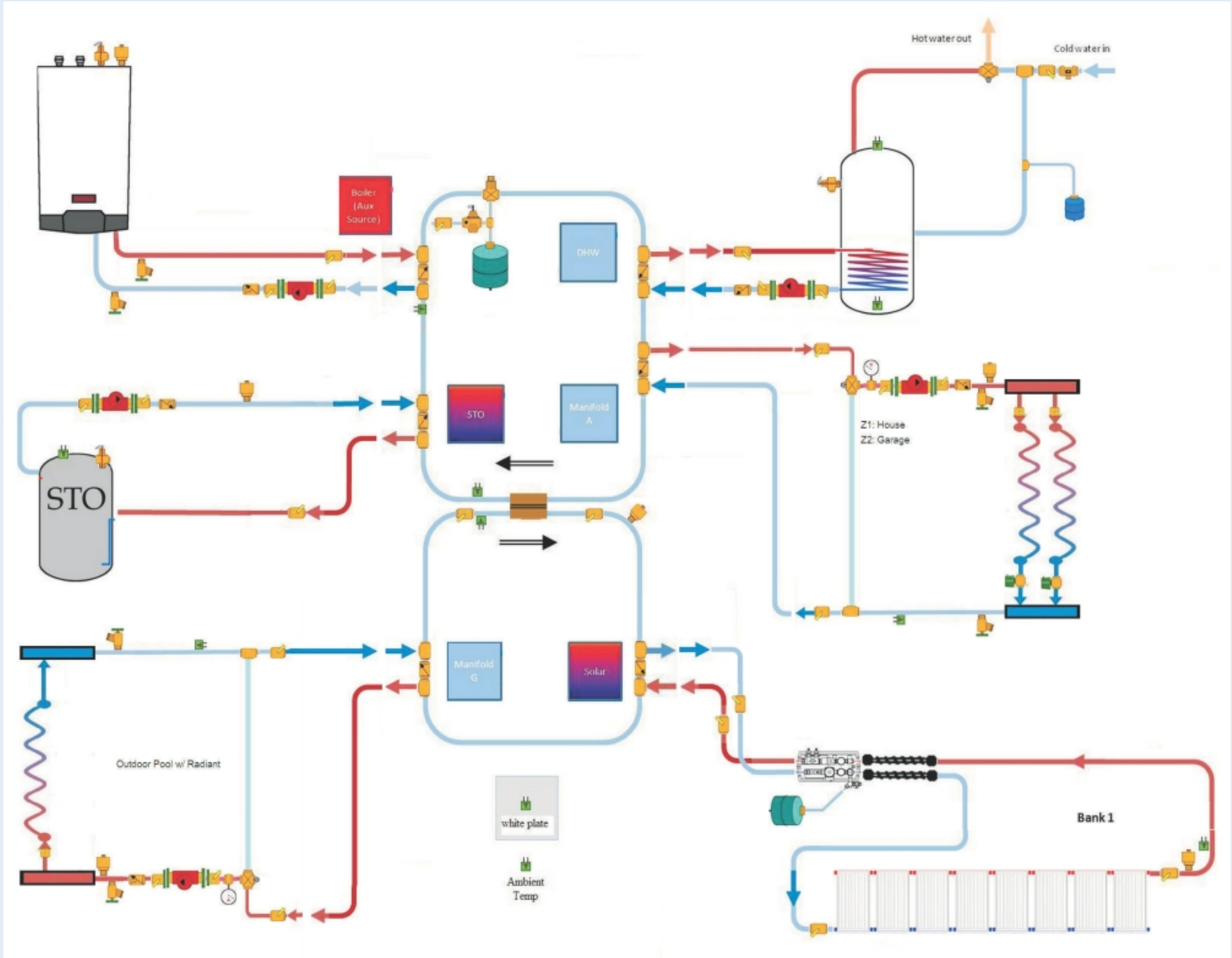
Standardized Plumbing

THE STANDARD PLUMBING CONFIGURATION is a DUAL PRIMARY LOOP – SIMPLE, YET REMARKABLY ADAPTABLE



SLASH-D Software Output Sample



The SolarLogic Philosophy

Good plumbing design is useless without good controls. Plumbing and controls must be thought of as two parts of the same task. Controls are not an afterthought.

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Total System Control:
We need to be controlling and monitoring all aspects of heat generation and distribution.

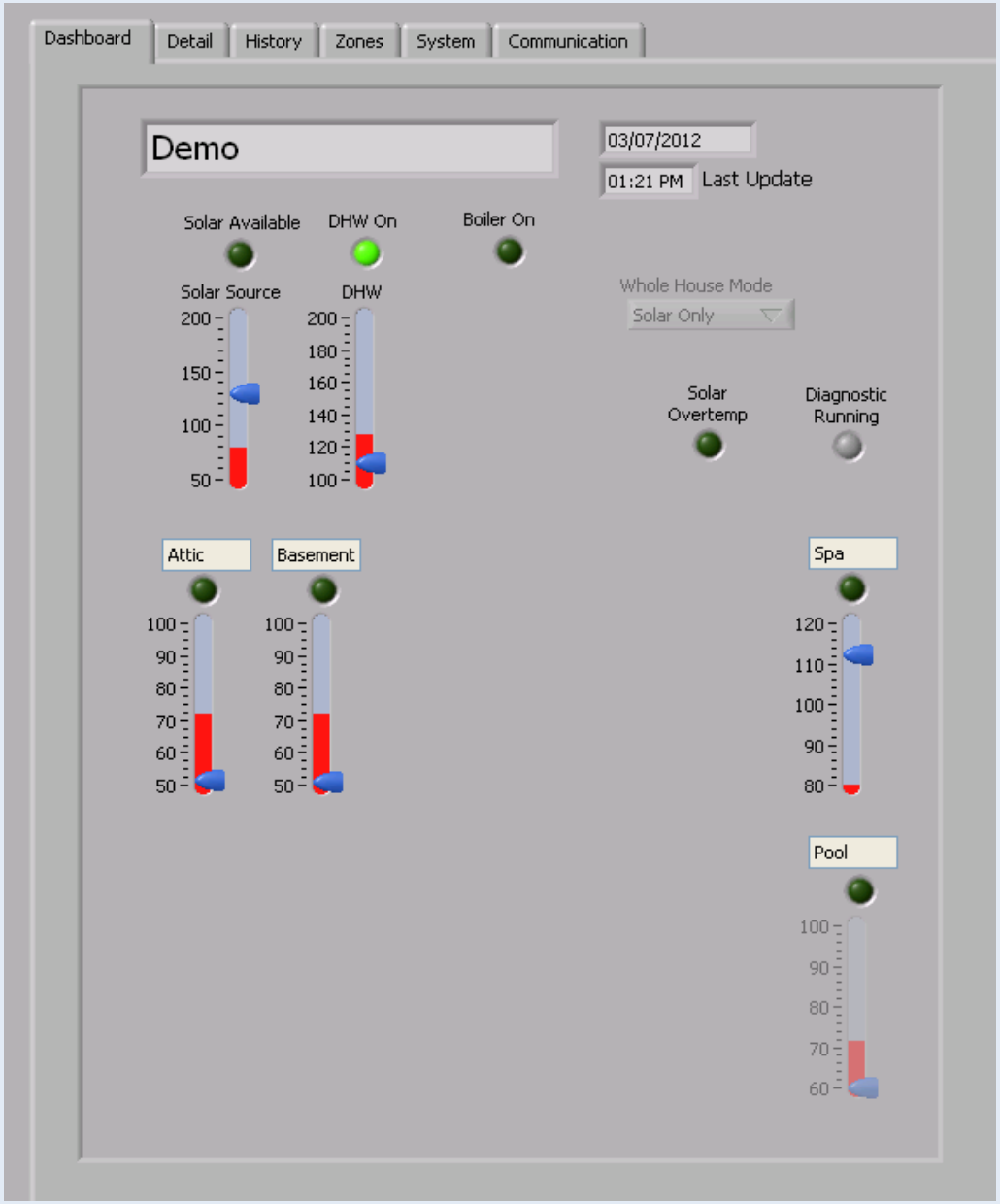
Total System Control

SolarLogic Generation II SLIC

A Complete System Control in One Box

- Controls ALL the heat sources and ALL the heat loads
- Accessible from anywhere on the internet, but not dependent on the internet
- Sophisticated software algorithms for the highest efficiency
- Simple to install – no programming, no wiring diagram
- Logs system history automatically from the moment you turn it on - over 250 data points every 5 minutes

Profitability is Enhanced by Remote Monitoring, Control and Diagnostics



Fingertip Comfort Control

A Familiar Thermostat for the Homeowner

- Straightforward comfort control in each room
- Prioritize for energy savings, precise temperature control, or a balance between the two
- Control the system with or without a computer

What does Monitoring and Control mean for the Solar Thermal Industry?

Demonstrable Results.

Happy Clients.

Happy, Profitable Installers :)

SOLARLOGIC

PRIME DIRECTIVE:

"It must feel like an upgrade."

Six Principles of Good Solar Thermal Design

1. Reliability
2. Effectiveness
3. Compatibility
4. Elegance
5. Serviceability
6. Efficiency

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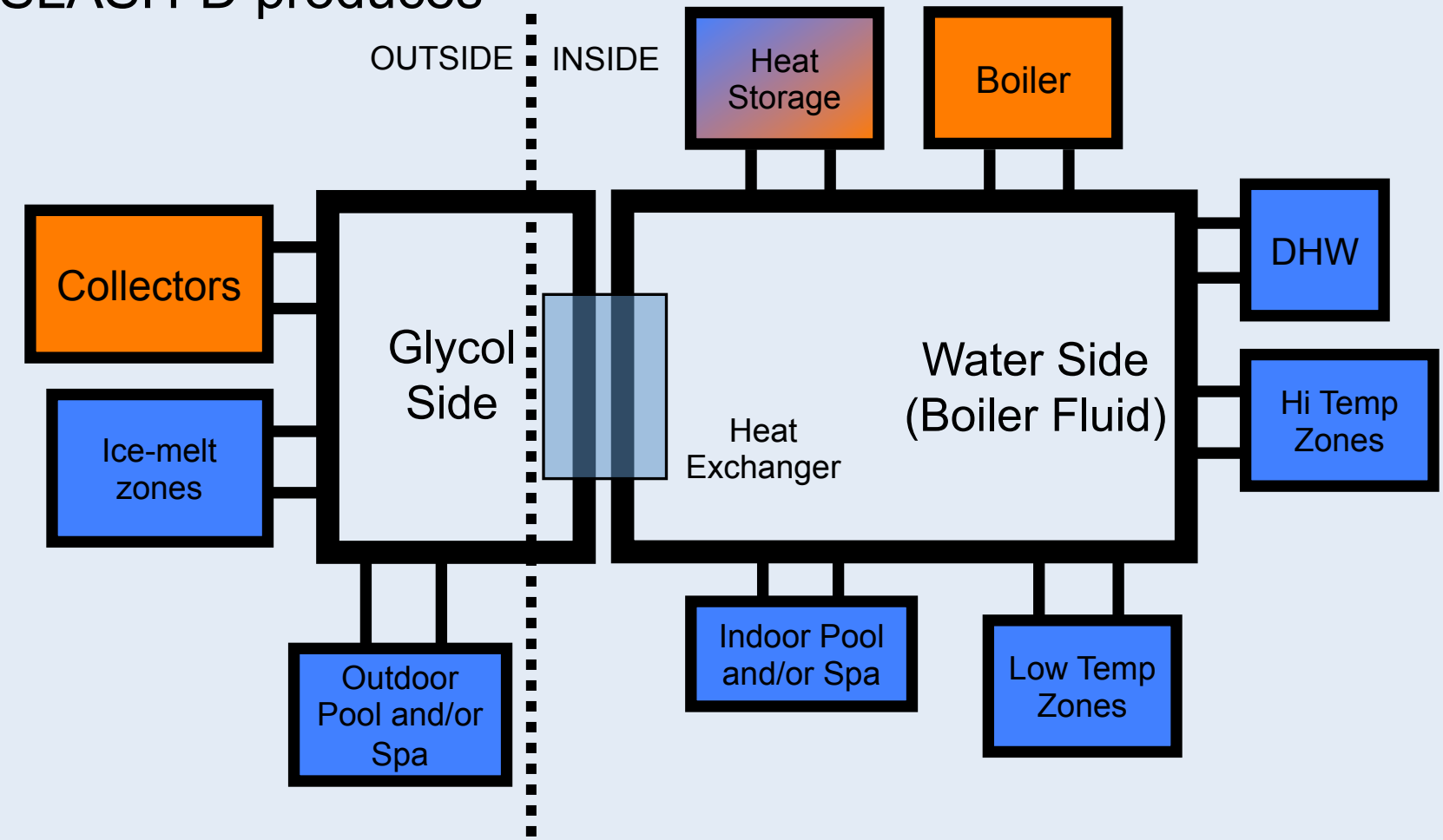
SolarLogic's Flagship Products: The SLASH-D Design Aid Website and the SLIC Controller

Overview – How the SLIC and the SLASH-D are Related

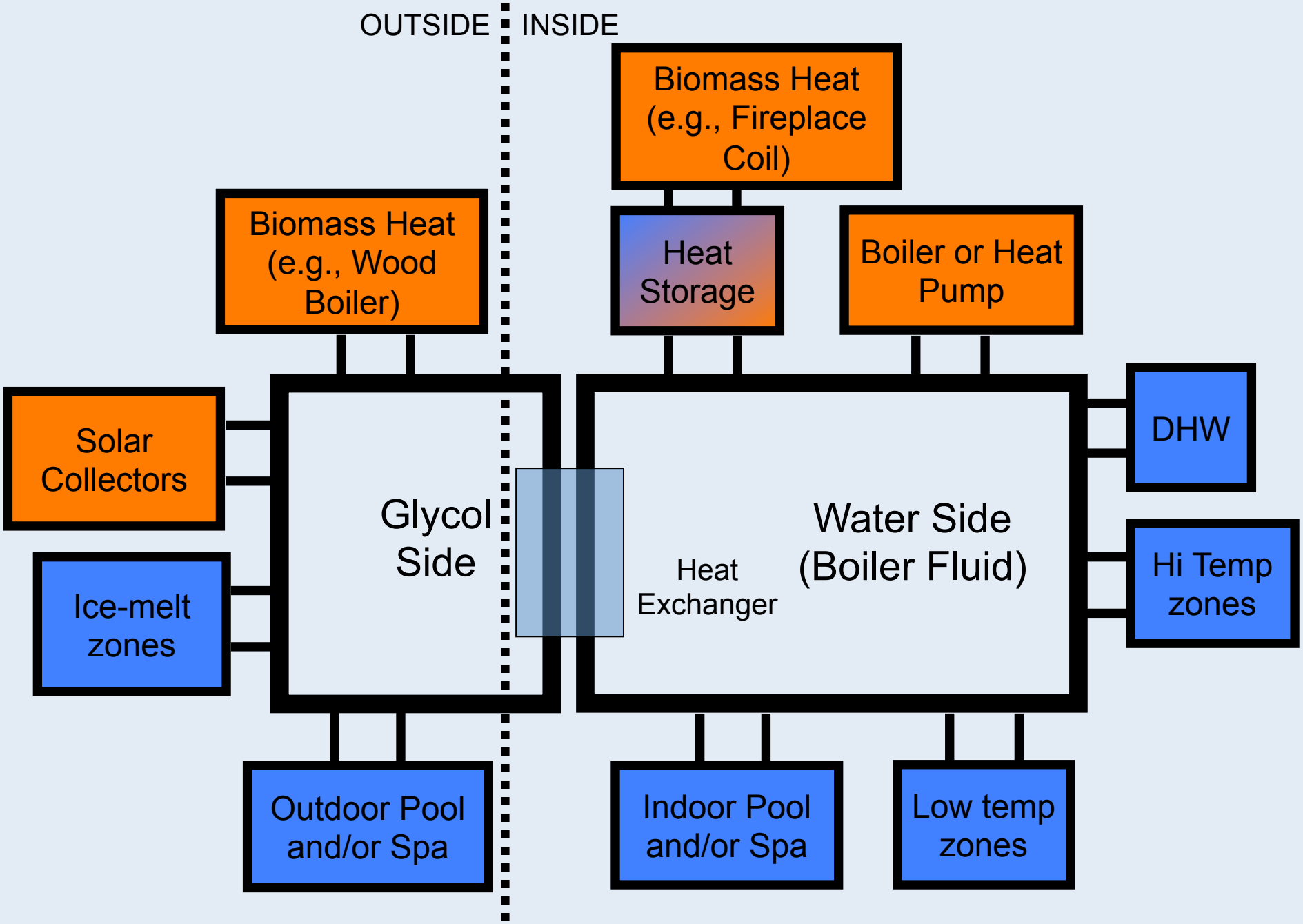
This is the SLASH-D, a design aid website: energy analysis, options exploration, system sizing, plumbing design and diagrams, parts lists

SolarLogic has Standardized the Combi-system Plumbing to a Primary/Secondary Configuration

1. The SLASH-D Always Designs a (Dual) Primary Loop System
2. The SLIC knows how to control Any System that the SLASH-D produces



LESS COMMON HEAT SOURCES ARE EASILY ACCOMODATED



This is the SLIC, an entire combi-system control in one box

Outside

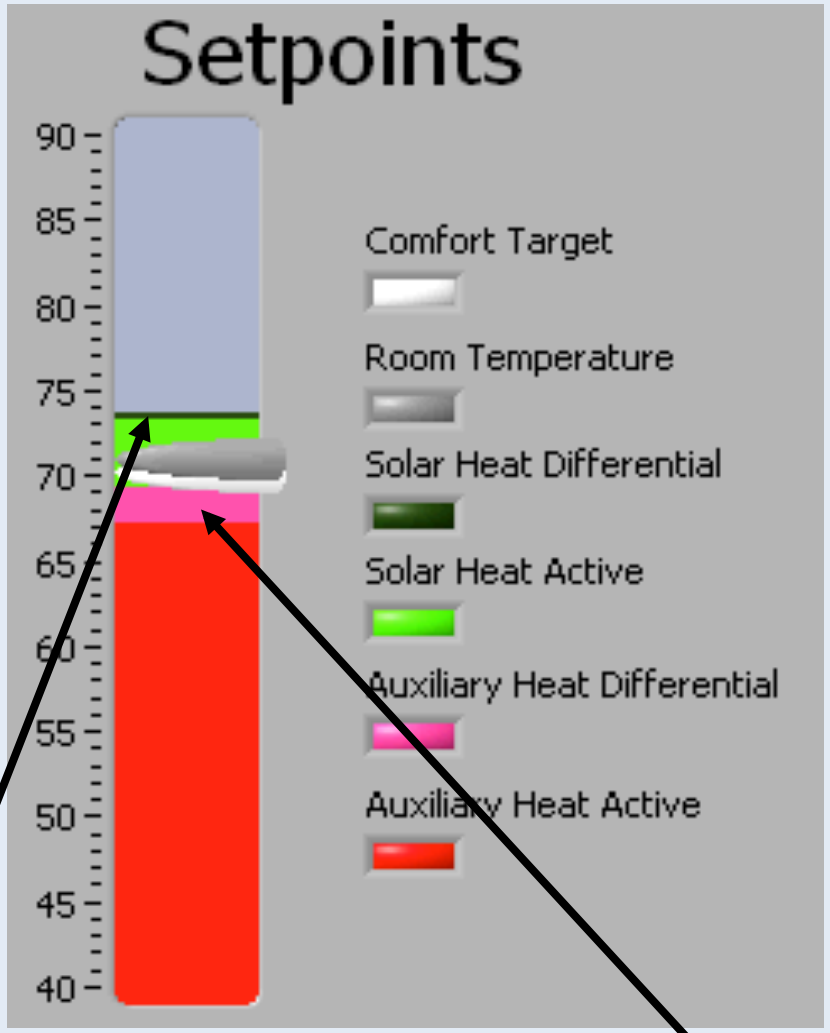
- Sophisticated software algorithms for every control decision
- Logs over 250 data points every 5 minutes automatically and keeps them forever

Inside

- Separately fused, pluggable relays
- Home run wiring
- Accessible on the internet but not dependent on the internet

The SLIC only works with SolarLogic Thermostats

Two-stage Heating is about Heat Banking in Mass (Masonry) Floors



Solar heat banking in the mass floor

Boiler called only when room is colder

Systems Tour

Pictures **Features**

Real-time visit **Data**

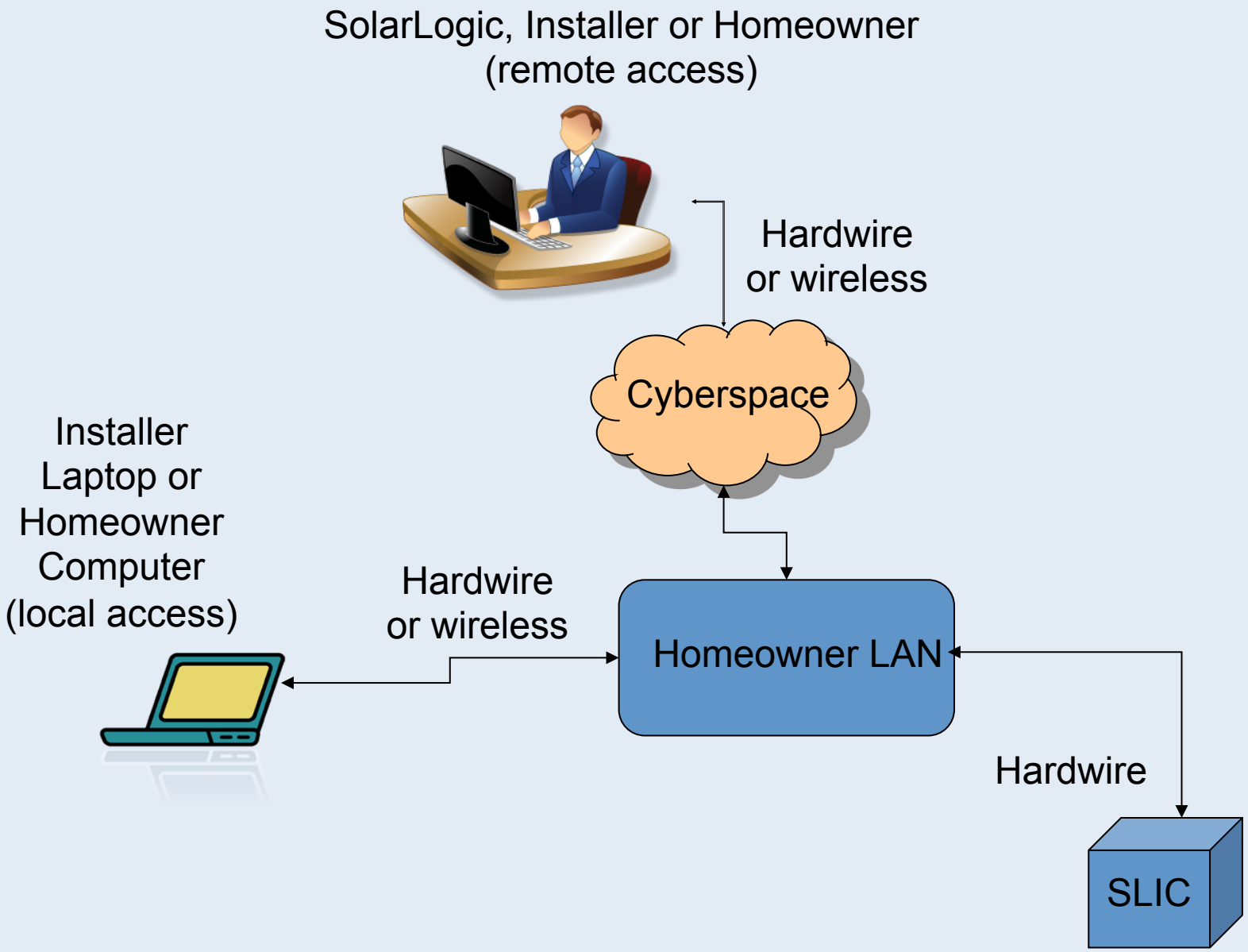
Interesting Investigations

Canyoncito, NM

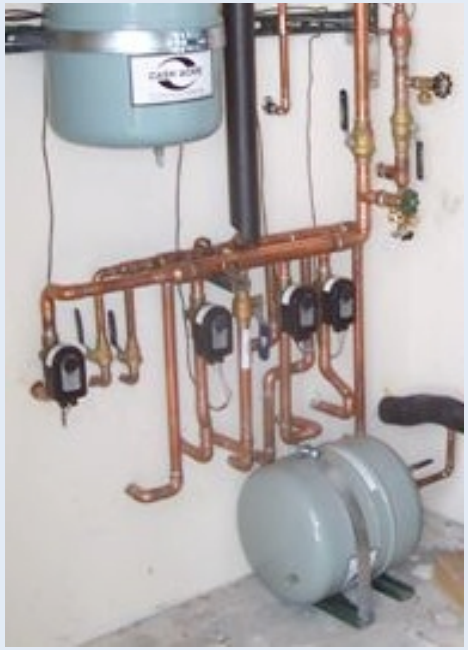
Diagram

Self-cooling Fins for Flat Plate Collectors
Fail-safe Overheat Protection

SLIC Access using the VSLIC program (Virtual SLIC)



Compact Dual Primary Loop Example:
Warm Concrete and DHW, Primary Loop on the Ceiling



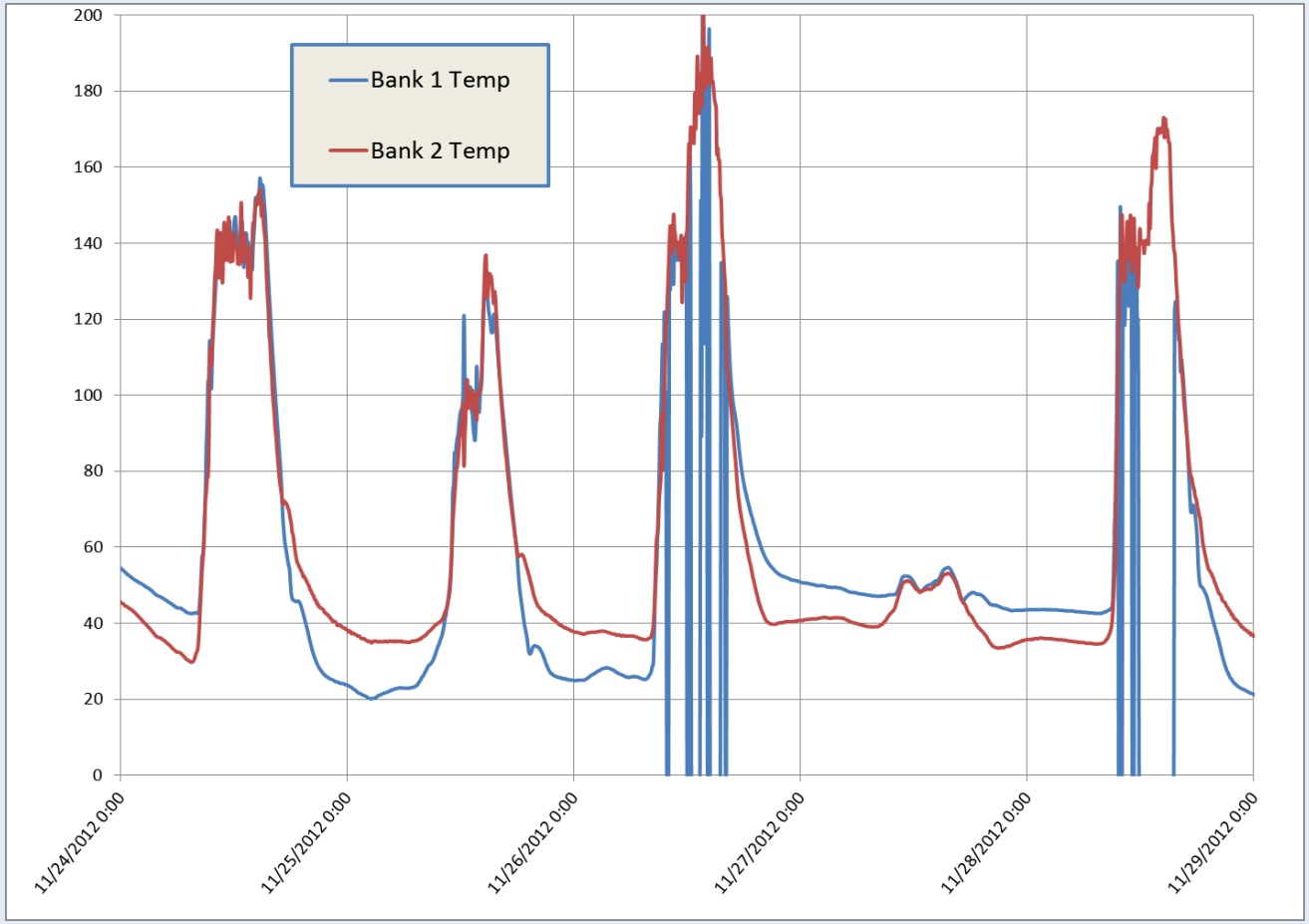
Barboursville, VA

Diagram

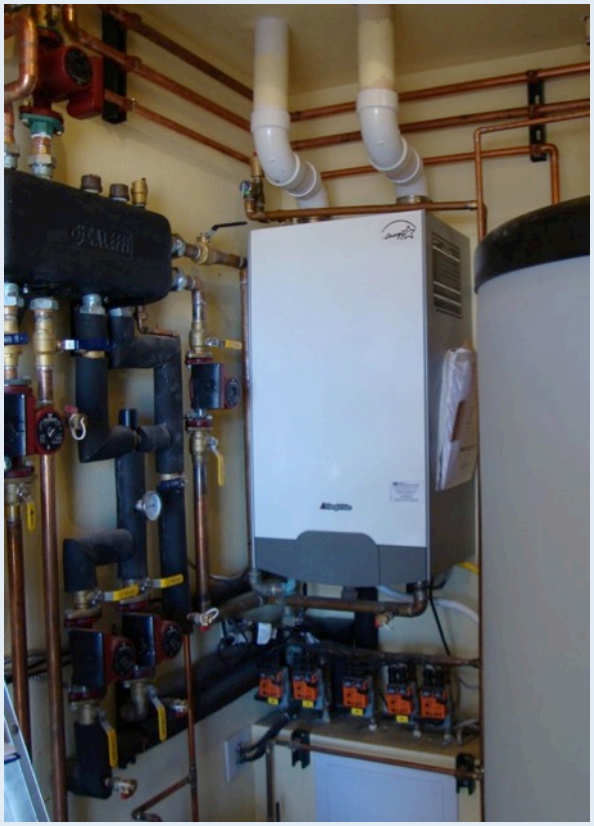
When the client calls and thinks there is a problem with the system:

1. Your first response is always to log on.
2. The next step is to analyze the log files.
3. If necessary, try the Diagnostic Mode.
4. If you still don't have an answer, call SolarLogic.
5. Your last resort is going to the site.

In this example, the customer thought there was a problem with one of his solar bank thermistors. He was right.



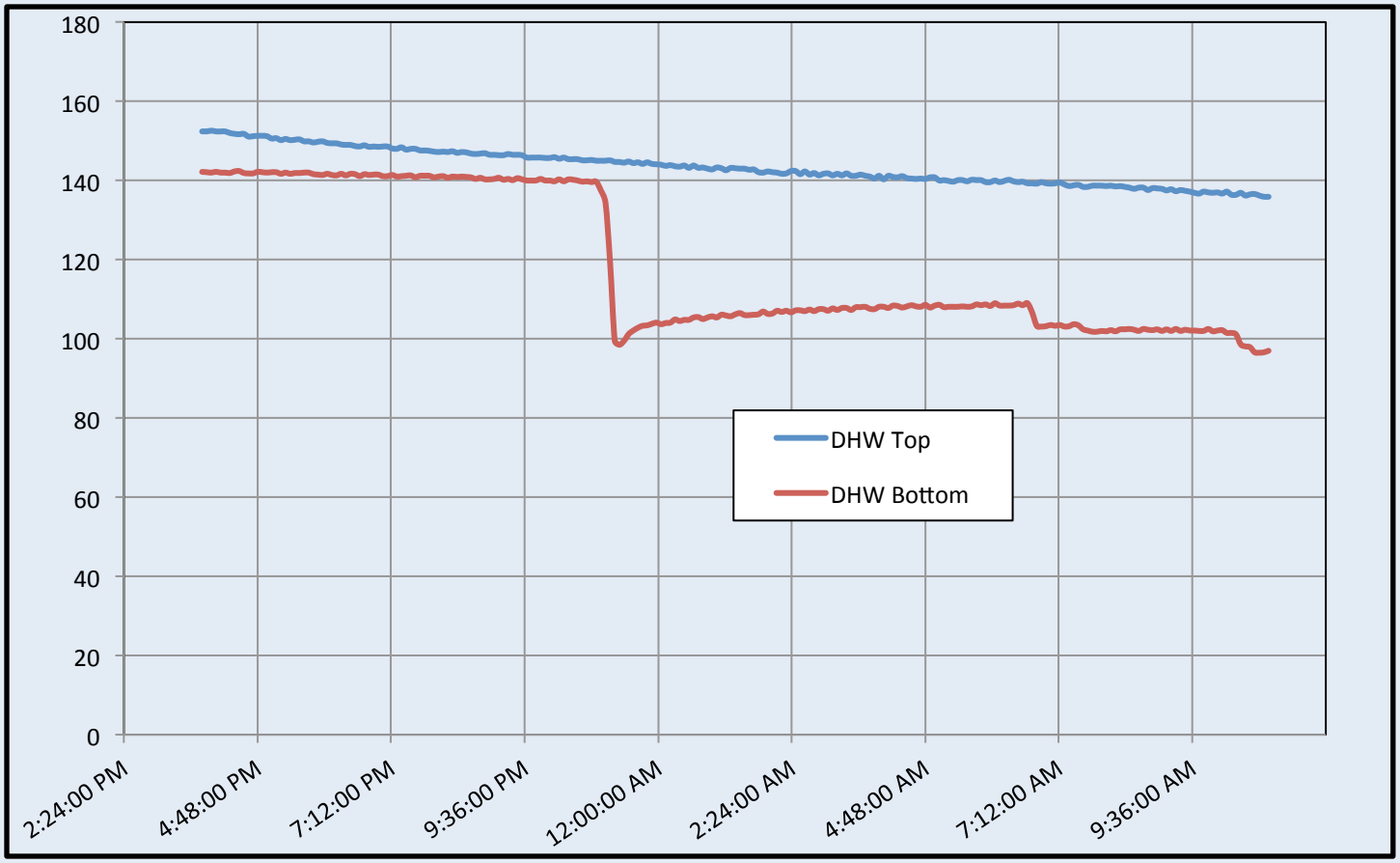
Santa Fe, NM



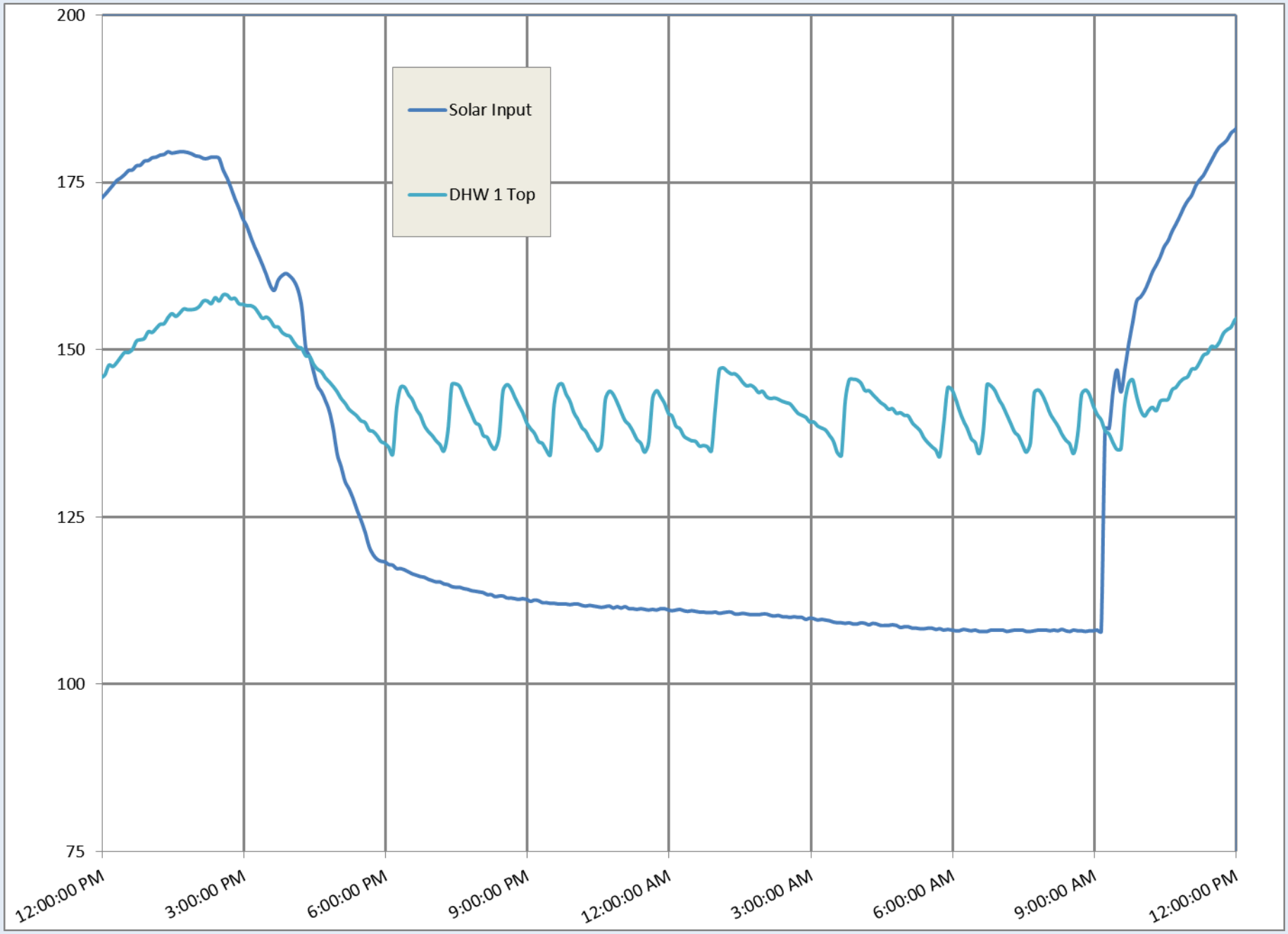
Sometimes the client is wrong, but you can still help them.

In this example, the customer thought there was a problem with the DHW production. He was wrong.

But, we were able to suggest where the plumber might look for the problem.



DHW Recirculators Cost Money. The Owners Rarely Realize How Much or Why.



So What Does Instant Hot Water Cost?

	24/7	timer (off midnight - 6AM)	timed-temp	demand-temp	no recirc
added cooling AC KWH	$ 155.54	$ 108.86	$ 133.41	$ 59.98	$ -
propane to maintain DHW temp	$ 948.29	$ 746.46	$ 593.46	$ 309.18	$ 141.00
boiler and DHW pump cost KWH	$ 56.65	$ 42.49	$ 31.74	$ 27.44	$ 8.36
recirc pump cost KWH	$ 72.48	$ 54.36	$ 27.18	$ 7.55	$ -
total cost of convenience	$ 1,232.95	$ 952.17	$ 785.78	$ 404.16	$ 149.36

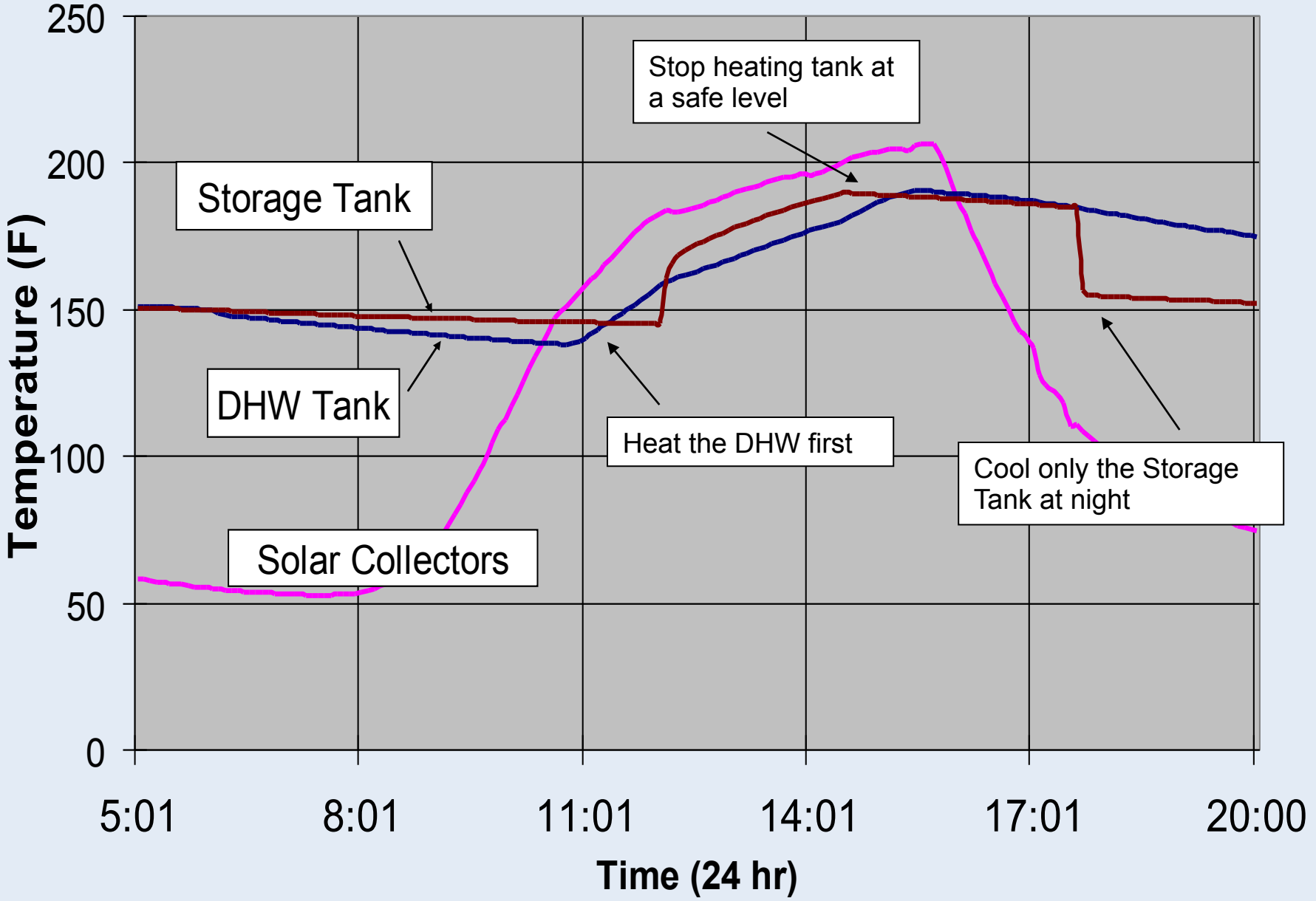
Heating Fuel \ Recirc Control	24/7	timer	timed-temperature	demand-temperature	no recirc
Propane	$ 1,233	$ 952	$ 786	$ 404	$ 149
Electricity	$ 1,207	$ 932	$ 770	$ 396	$ 146
Fuel Oil	$ 1,155	$ 891	$ 737	$ 379	$ 138
Natural Gas	$ 568	$ 429	$ 370	$ 187	$ 51

What does a Log File Look Like?

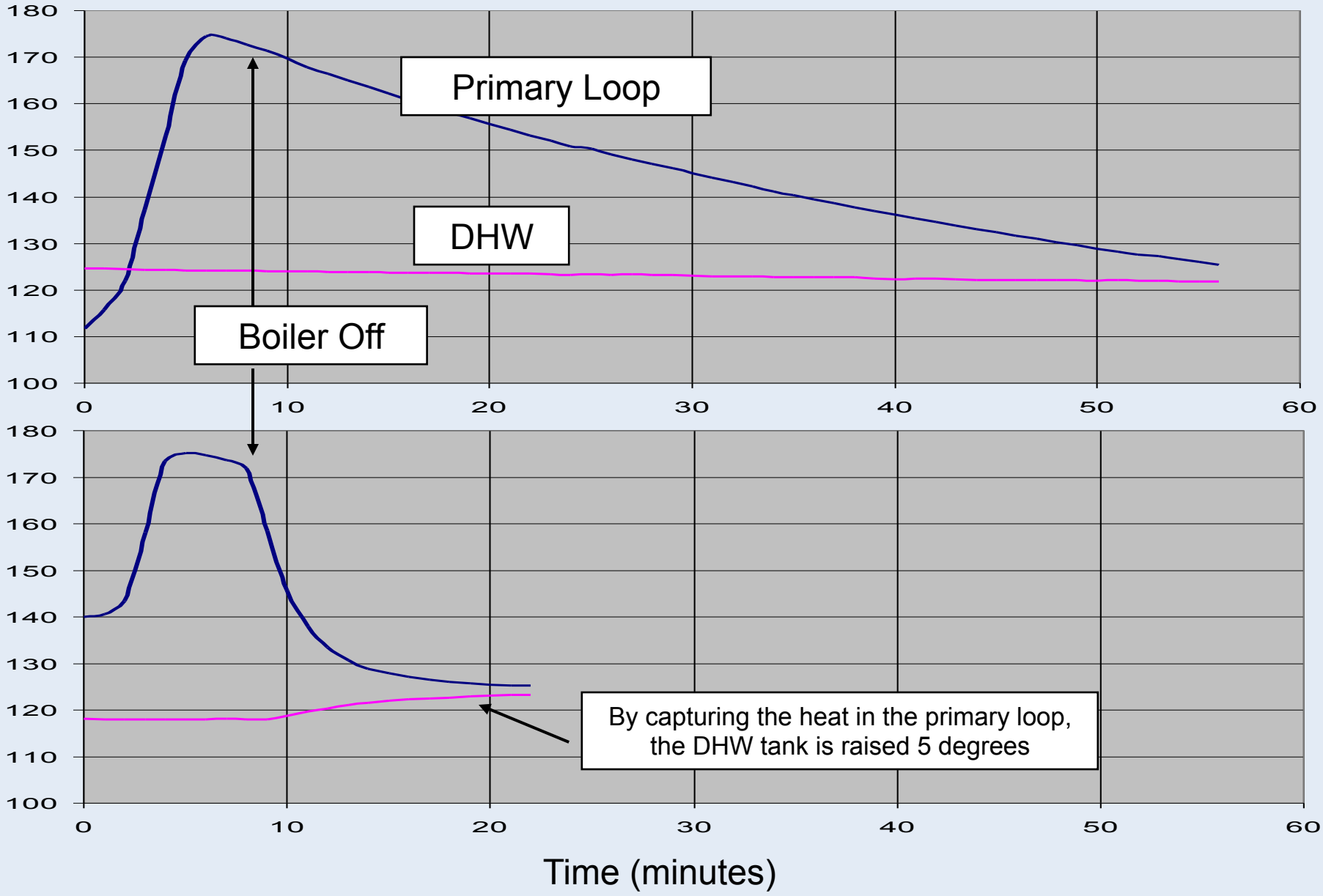
K8 | fx | 71.8

	A	B	C	D	E	F	G	H	I	J	K	
1	GMT	Local Time	Bank 1 Temp	Bank 2 Temp	Solar Input	Cooling Panels	White Plate	Ambient	Post HX	FC	Pre HX (BTU)	DH
2	3/1/2012 0:03	2/29/2012 17:03	99.9	-6.1	101.2	-6.1	53.8	52.9	104	92.8	72.6	
3	3/1/2012 0:09	2/29/2012 17:09	96.1	-6.1	98	-6.1	53	52.5	102.4	92.1	72.4	
4	3/1/2012 0:14	2/29/2012 17:14	92.1	-6.1	94.9	-6.1	52.2	51.9	100.6	91.4	72.3	
5	3/1/2012 0:19	2/29/2012 17:19	87.4	-6.1	92.3	-6.1	51.7	51.5	99.1	90.9	72.2	
6	3/1/2012 0:25	2/29/2012 17:25	87.4	-6.1	90.2	-6.1	51.1	50.9	97.7	90.3	72	
7	3/1/2012 0:30	2/29/2012 17:30	86	-6.1	88.1	-6.1	50.3	50	96.4	89.8	71.9	
8	3/1/2012 0:35	2/29/2012 17:35	85.1	-6.1	86.5	-6.1	49.8	49.6	95.1	89.3	71.8	
9	3/1/2012 0:41	2/29/2012 17:41	81.2	-6.1	84.9	-6.1	49.1	49	93.8	88.8	71.6	
10	3/1/2012 0:46	2/29/2012 17:46	77.6	-6.1	83.5	-6.1	48.5	48.2	92.7	88.3	71.4	
11	3/1/2012 0:51	2/29/2012 17:51	73.9	-6.1	82.3	-6.1	47.8	47.5	91.6	87.8	71.1	
12	3/1/2012 0:57	2/29/2012 17:57	70.6	-6.1	81.2	-6.1	47.2	46.7	90.6	87.3	70.9	
13	3/1/2012 1:02	2/29/2012 18:02	64.8	-6.1	80.2	-6.1	46.5	45.9	89.6	86.8	70.7	
14	3/1/2012 1:07	2/29/2012 18:07	62.5	-6.1	79.3	-6.1	45.8	44.8	88.7	86.4	70.5	
15	3/1/2012 1:13	2/29/2012 18:13	64.2	-6.1	78.5	-6.1	45.3	44.6	87.7	85.9	70.2	
16	3/1/2012 1:18	2/29/2012 18:18	60.8	-6.1	77.7	-6.1	44.7	43.5	86.9	85.4	70	
17	3/1/2012 1:24	2/29/2012 18:24	58.1	-6.1	77.1	-6.1	44	42.8	86	84.9	69.8	
18	3/1/2012 1:29	2/29/2012 18:29	55.8	-6.1	76.4	-6.1	43.3	41.1	85.2	84.5	69.6	
19	3/1/2012 1:34	2/29/2012 18:34	54.6	-6.1	75.8	-6.1	42.6	40.3	84.4	84	69.3	
20	3/1/2012 1:40	2/29/2012 18:40	52.7	-6.1	75.3	-6.1	42	39.9	83.6	83.6	69.1	
21	3/1/2012 1:45	2/29/2012 18:45	51.1	-6.1	74.7	-6.1	41.5	40.6	82.9	83.2	68.8	
22	3/1/2012 1:51	2/29/2012 18:51	49.4	-6.1	74.2	-6.1	41.1	40.3	82.2	82.7	68.7	
23	3/1/2012 1:56	2/29/2012 18:56	47.8	-6.1	73.8	-6.1	40.6	38.7	81.6	82.3	68.5	
24	3/1/2012 2:01	2/29/2012 19:01	46.2	-6.1	73.3	-6.1	40.2	39.1	80.9	81.9	68.3	
25	3/1/2012 2:07	2/29/2012 19:07	44.9	-6.1	72.9	-6.1	40	38.1	80.3	81.5	68.2	
26	3/1/2012 2:12	2/29/2012 19:12	43.9	-6.1	72.6	-6.1	39.6	38.9	79.7	81.1	68	
27	3/1/2012 2:18	2/29/2012 19:18	43	-6.1	72.2	-6.1	39.5	39.3	79.1	80.6	67.8	
28	3/1/2012 2:23	2/29/2012 19:23	42.2	-6.1	71.9	-6.1	39.3	39.4	79.1	80.5	67.6	
29	3/1/2012 2:29	2/29/2012 19:29	41.4	-6.1	71.6	-6.1	38.9	38.5	110.9	124.2	67.5	
30	3/1/2012 2:32	2/29/2012 19:32	41	-6.1	71.4	-6.1	38.7	37.5	108.7	120.3	67.5	

Log file analysis showing fine control of heating and cooling of the DHW and Storage tanks during the summer



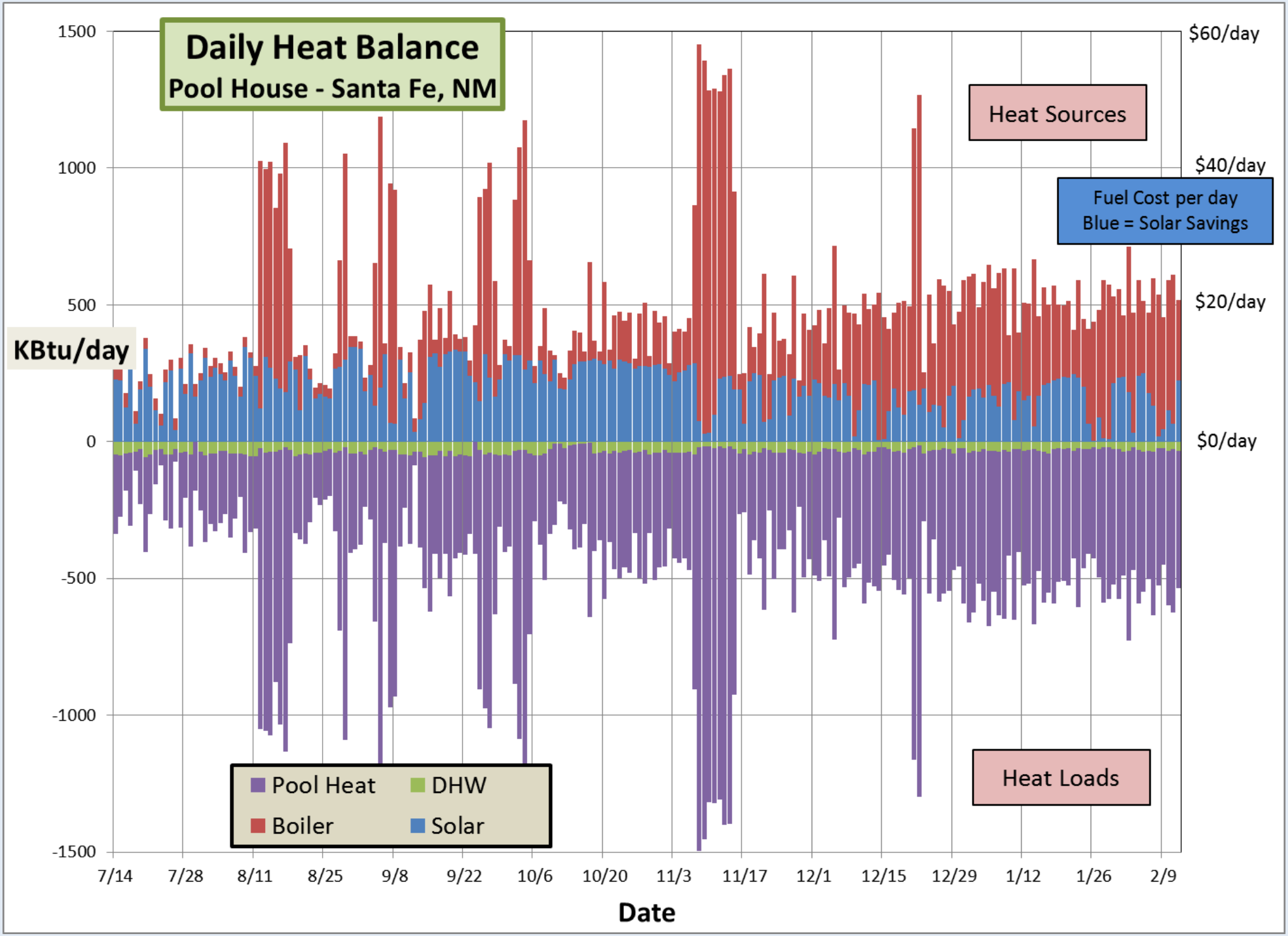
Log file analysis showing stranded heat recapture. For this system, 2000 BTUs can be captured every time the boiler turns off.



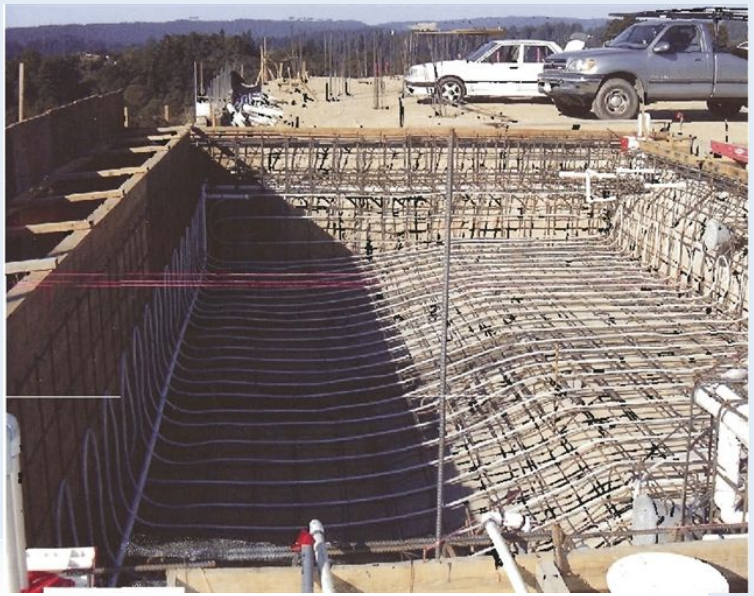
Santa Fe, NM

Diagram

Diagram


Daily Heat Balance
Pool House - Santa Fe, NM
Heat Sources
Fuel Cost per day
Blue = Solar Savings
Heat Loads
KBtu/day
1500
1000
500
0
-500
-1000
-1500
$60/day
$40/day
$20/day
$0/day
Pool Heat
DHW
Boiler
Solar
7/14
7/28
8/11
8/25
9/8
9/22
10/6
10/20
11/3
11/17
12/1
12/15
12/29
1/12
1/26
2/9
Date

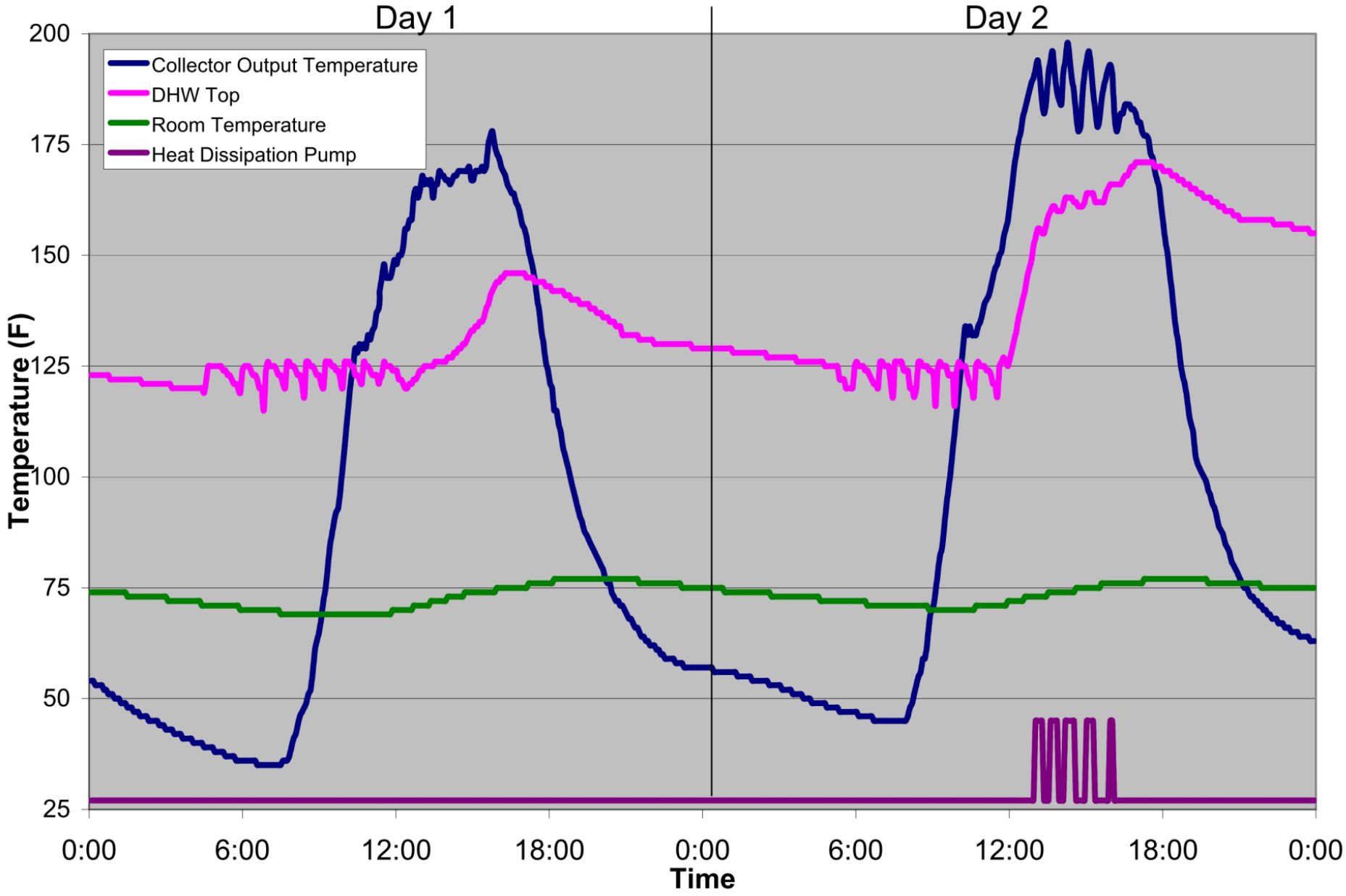
Single Primary Loop Example:
Warm Concrete, DHW, Radiant Pool in a “District” Design



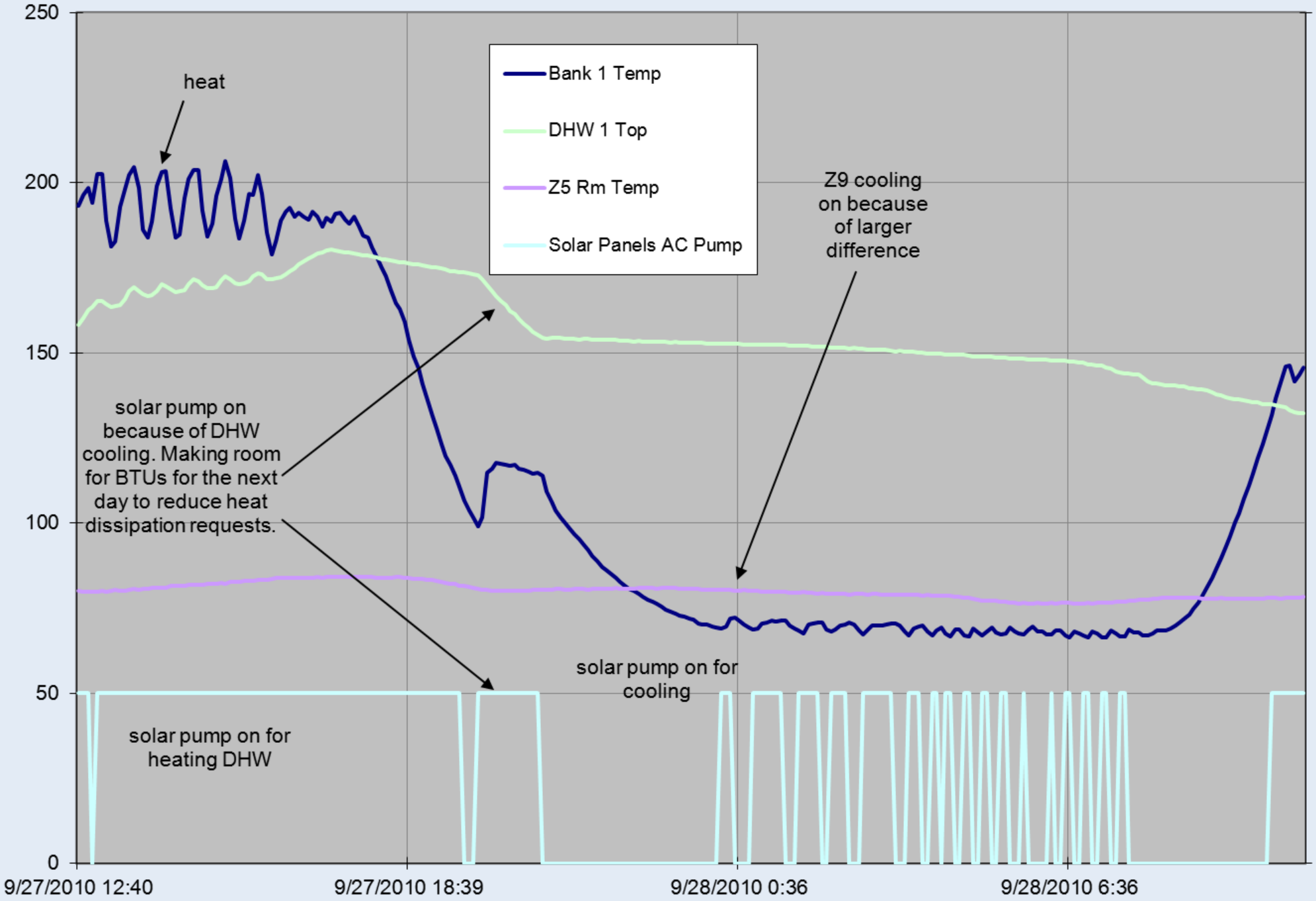
Placitas, NM

Diagram

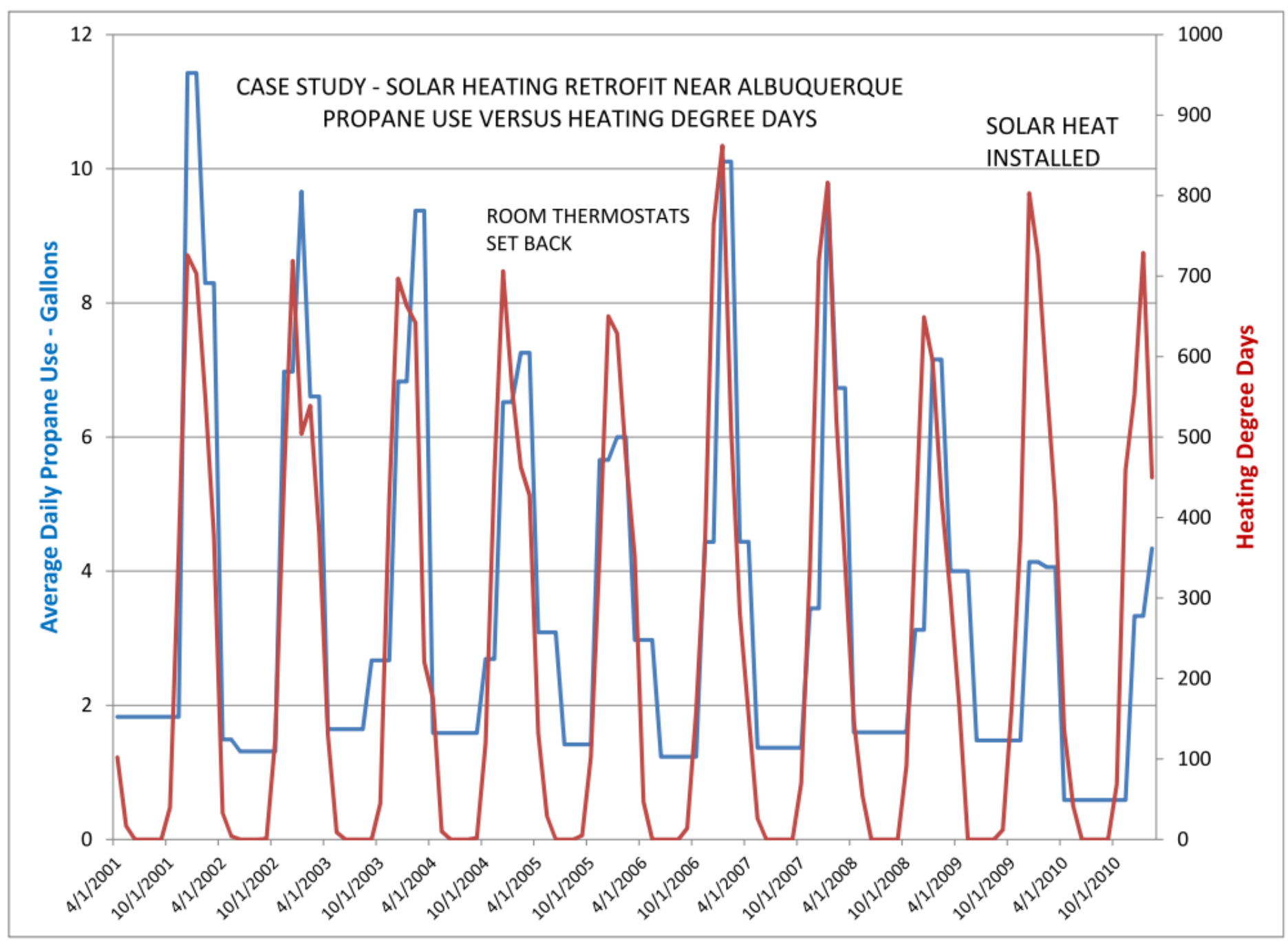
Another Method for Overheat Protection: Intelligent Heat Dissipation



NSRC: DHW Pre-cooling for Heat Buffering and Zone Cooling



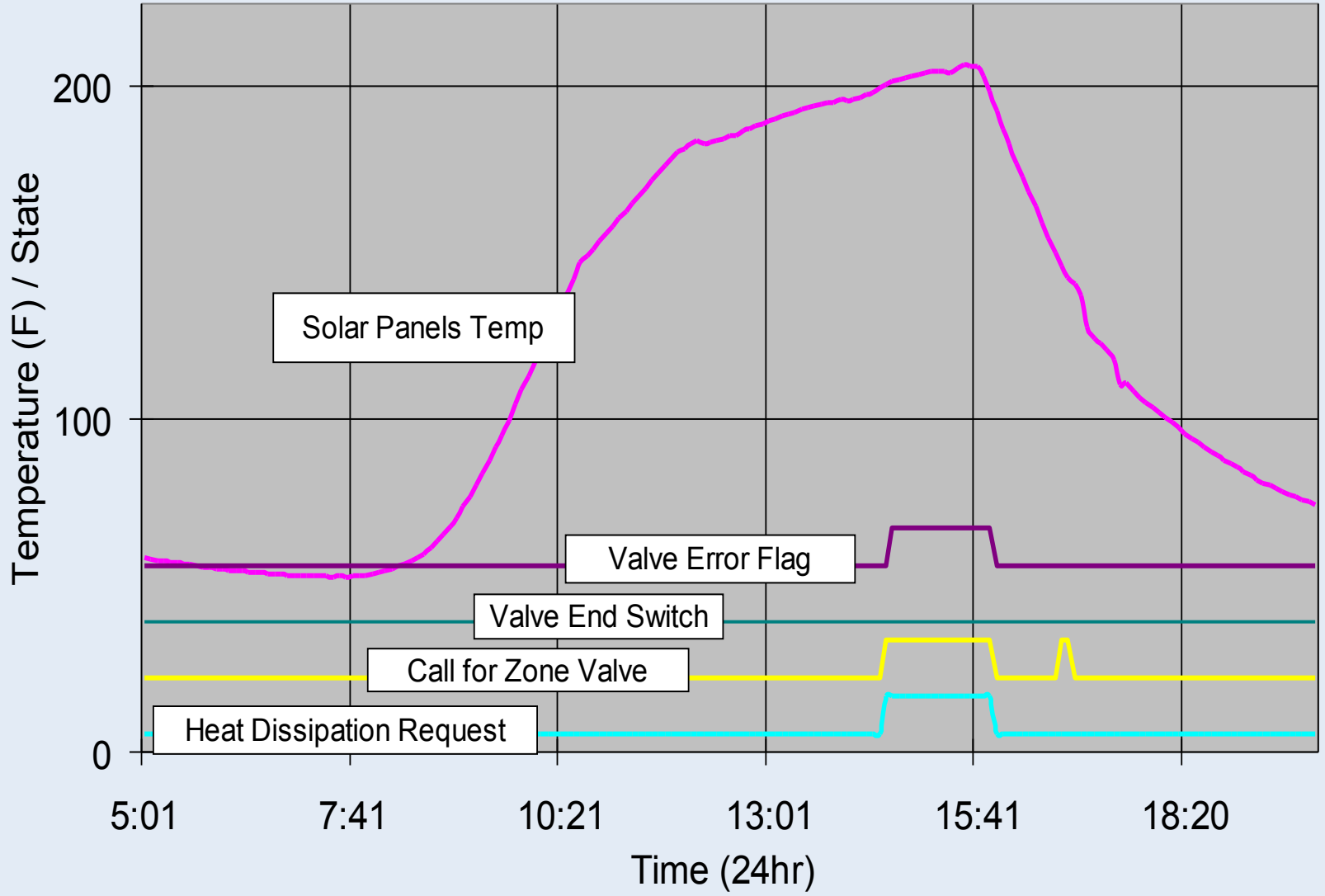
Owner's Own Analysis: System Saves 50% of Annual Propane Plus Lowers A/C by 20% in Summer



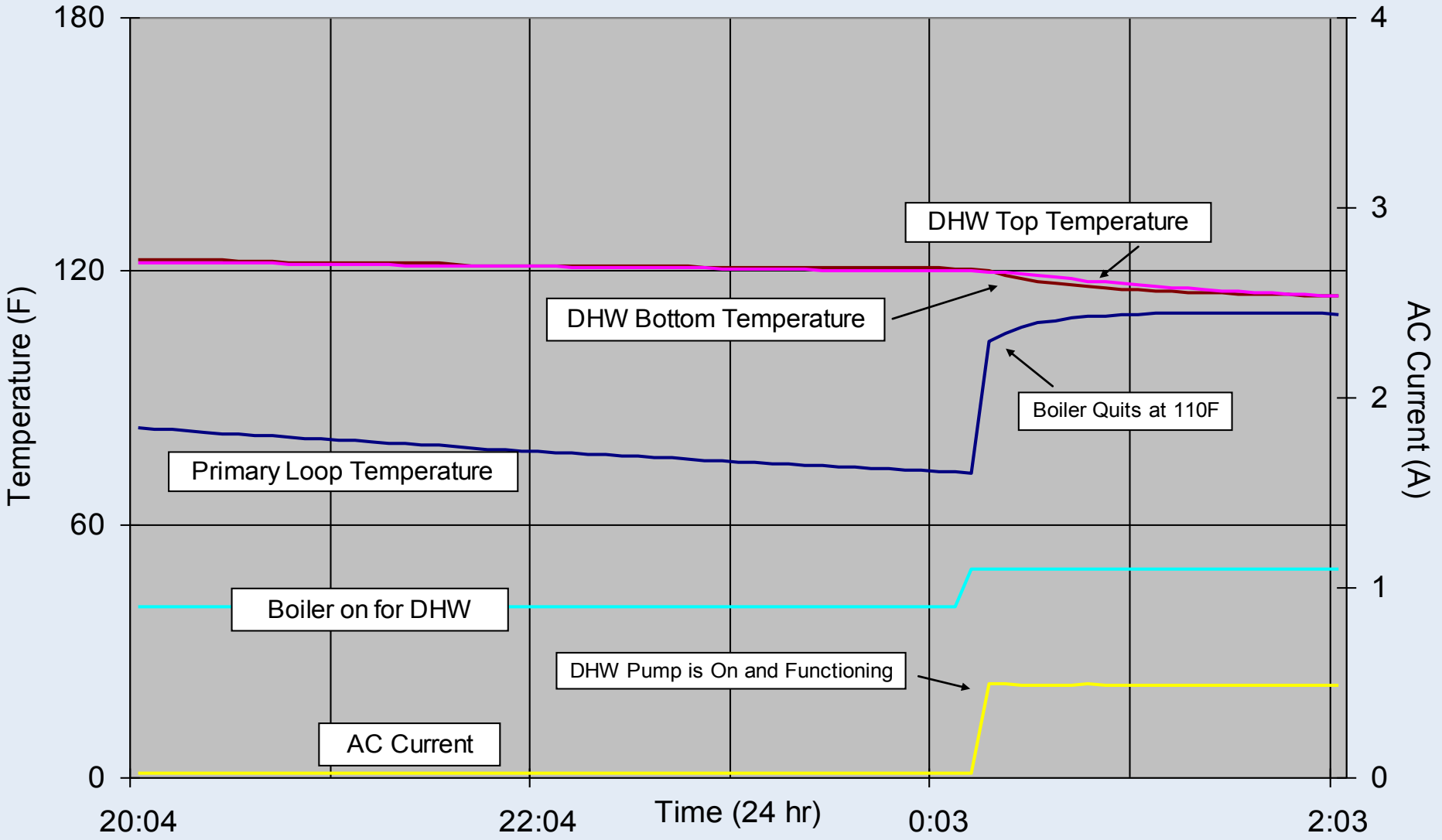
Award-Winning Los Alamos
County Eco-station
Los Alamos, NM

Diagram

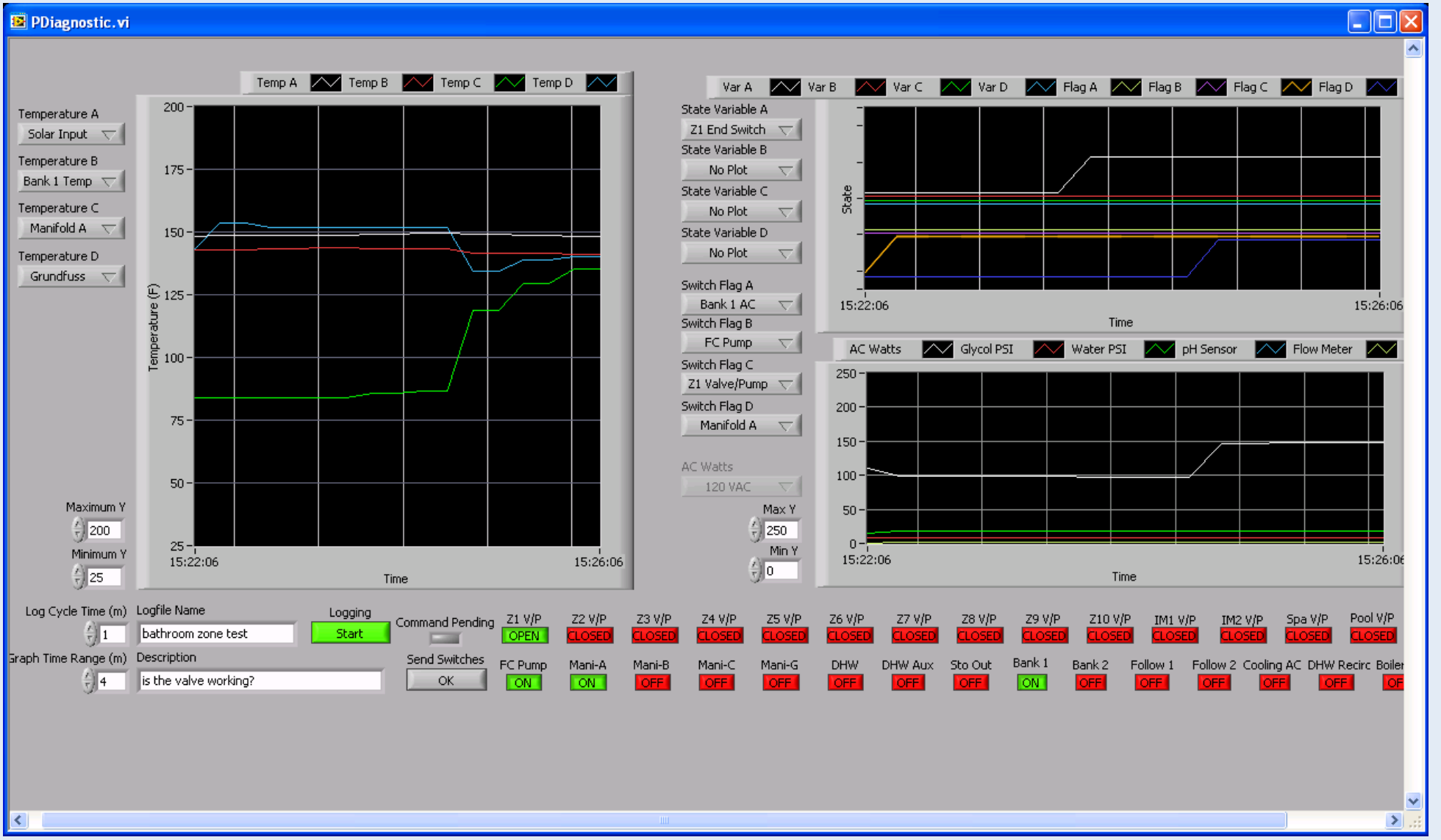
The SolarLogic Central Server will send an “Alert” email when a valve failure occurs. Log file analysis showing a valve failure captured by the lack of an end switch signal after a wait time of 5 minutes.



The SolarLogic Central Server will send an “Alert” email when DHW is more than 15 degrees below the “DHW Minimum” for more than 20 minutes. Log file analysis showing boiler failure when there was a call to make boiler DHW.

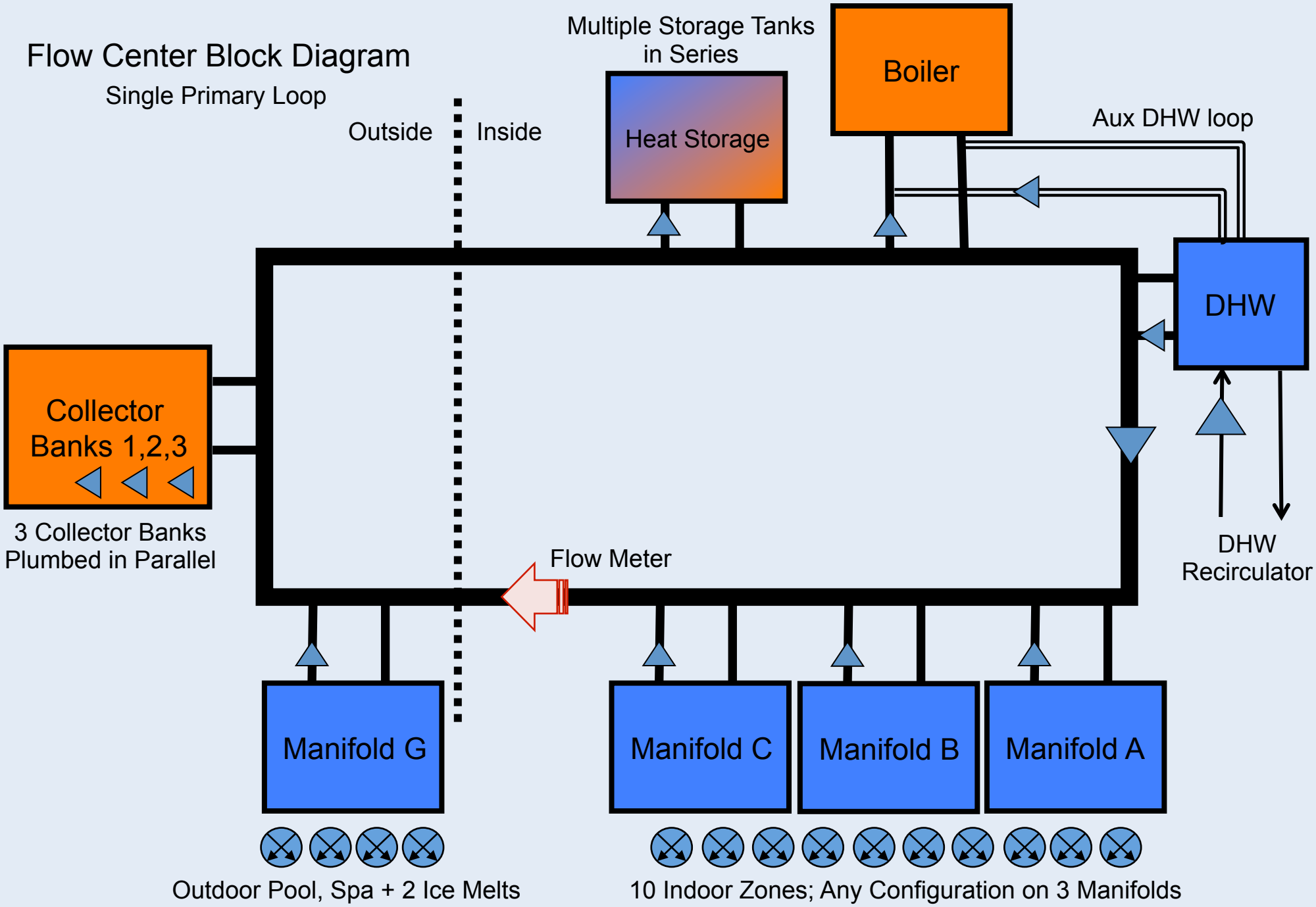


The Diagnostic Mode is used for Commissioning and Troubleshooting

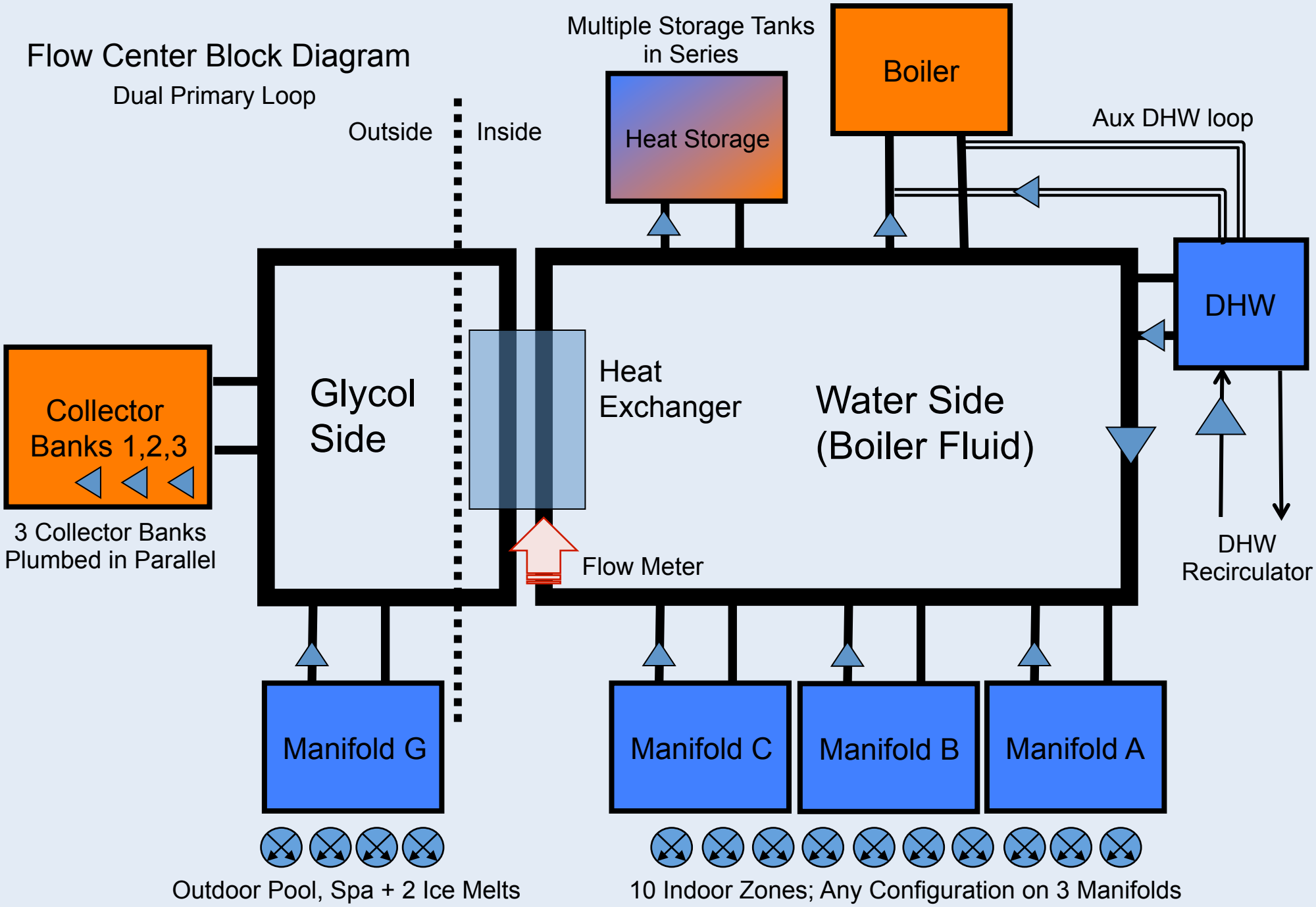


Designing the Solar Heating System: the SLASH-D

SLASH-D and SLIC Maximum Configuration: Glycol Direct

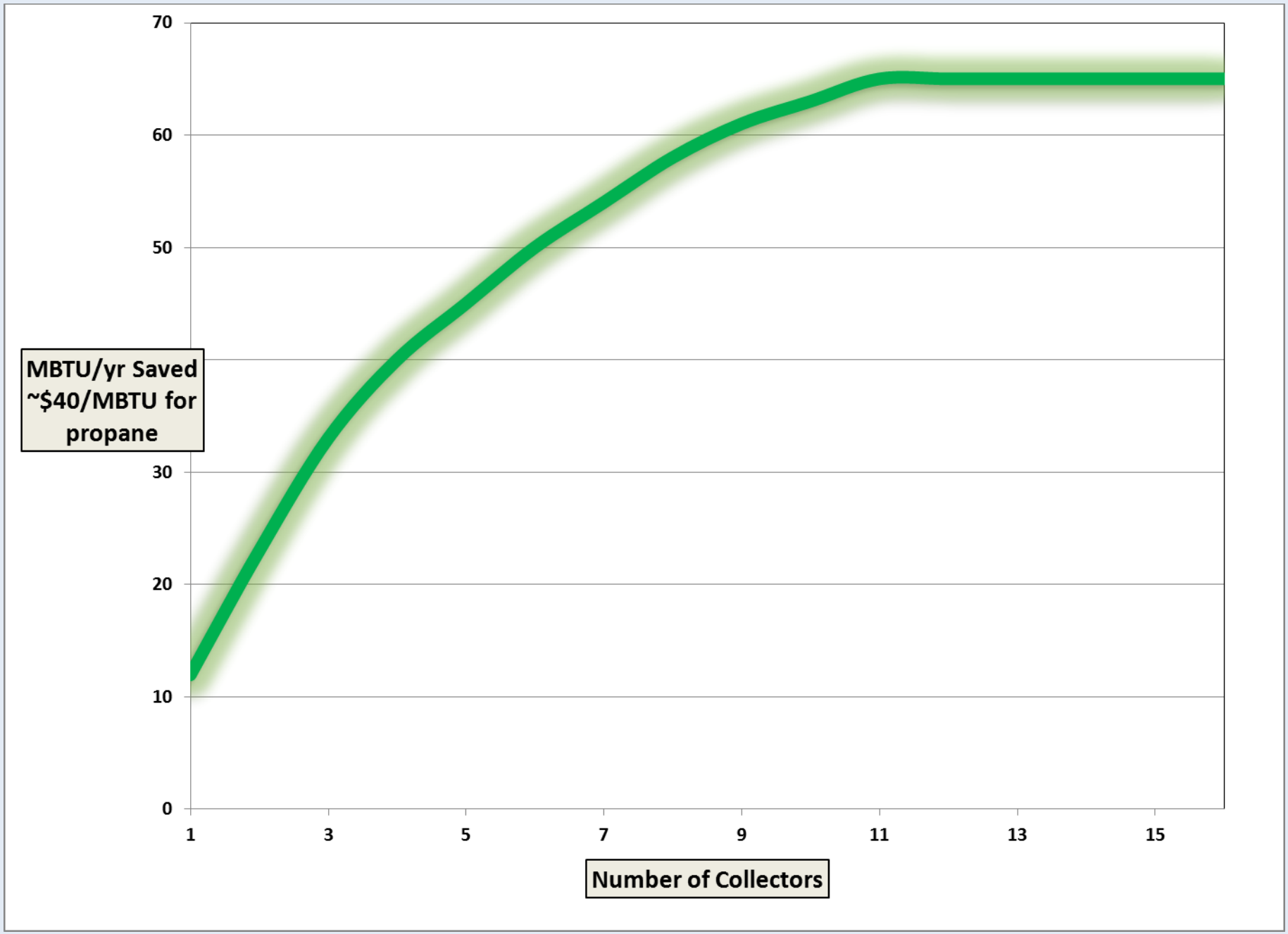


SLASH-D and SLIC Maximum Configuration: Dual Primary Loop



Live Demonstration: Using the SLASH-D

By Overriding the SLASH-D Recommended Number of Panels, you can Study the Cost/Benefit of Adding More



SLASH-D Exercise
(Individual or Small Group)

- Design the example homes in the SLASH-D Exercise Handout

Selling Solar Combisystems: Battling “Sticker Shock”

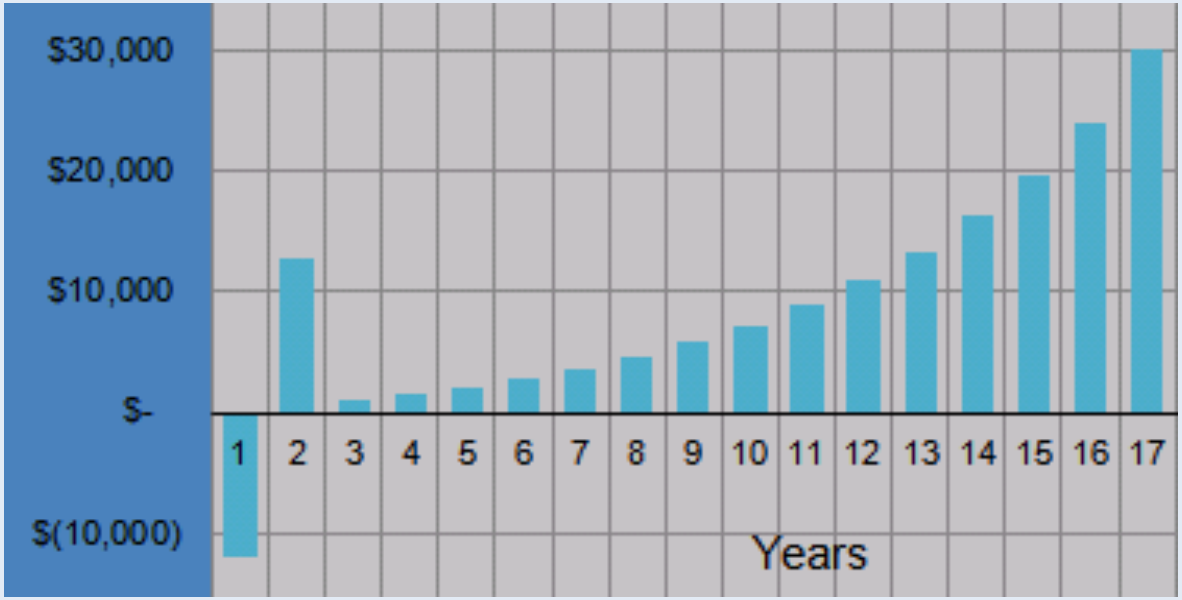
Customers have been trained to ask the Financial Question: How many years until Payback? They should be looking at Cashflow and Financing the System

Years 1 & 2: Net outlay balanced by tax rebates.

Thereafter: Net cash into their pockets every year – **Including servicing the loan payments!**

Enormous savings that pile up year after year.

Energy prices are <u>not</u> stable.



Actual 20-year average annual price of fuel increases:
Fuel oil & propane – 20%
Electricity – 3%
Natural gas – 7%

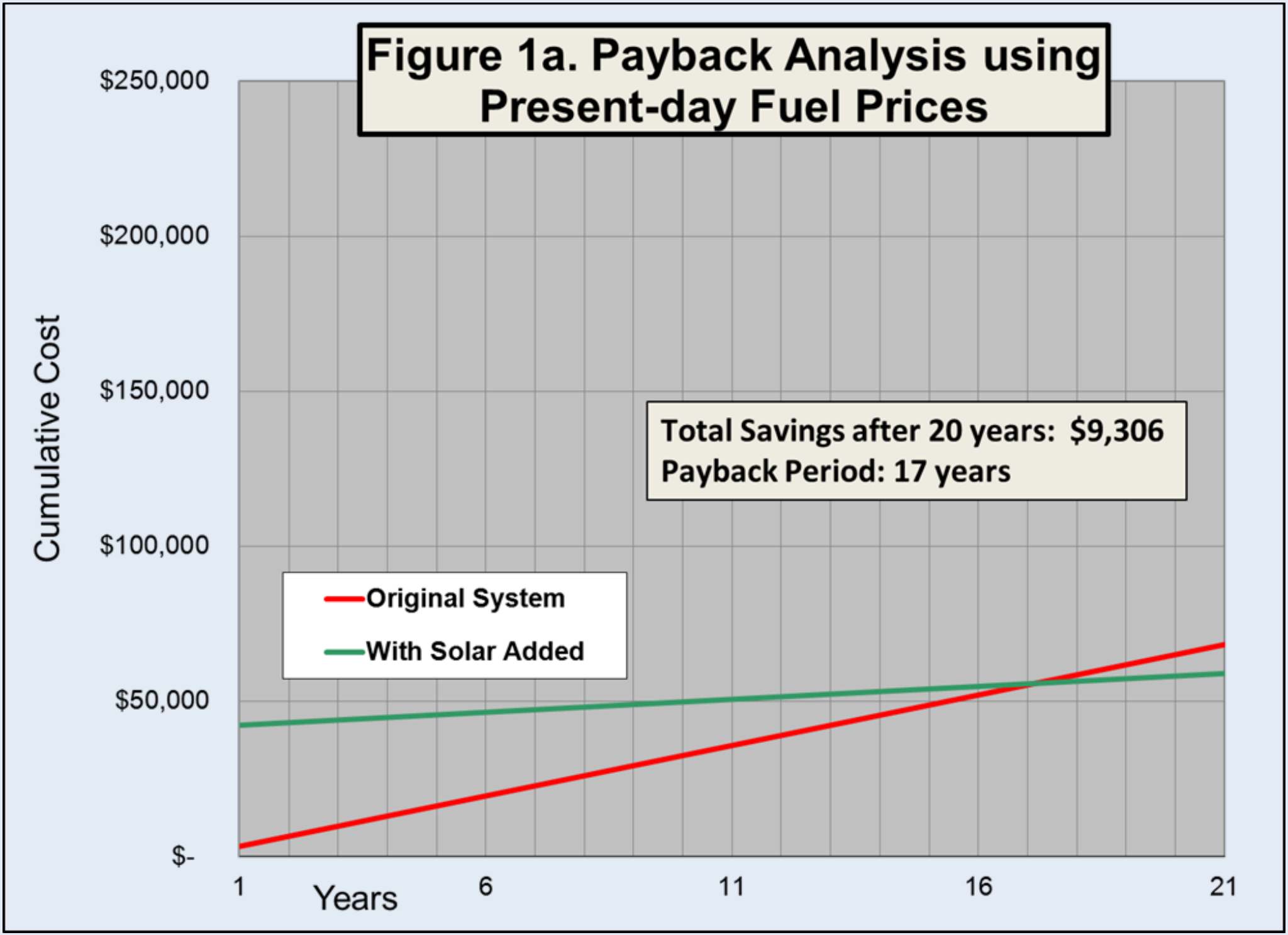


Figure 1a. Payback Analysis using Present-day Fuel Prices
$250,000
$200,000
$150,000
$100,000
$50,000
$-
Cumulative Cost
1
6
11
16
21
Years
Total Savings after 20 years: $9,306
Payback Period: 17 years
Original System
With Solar Added

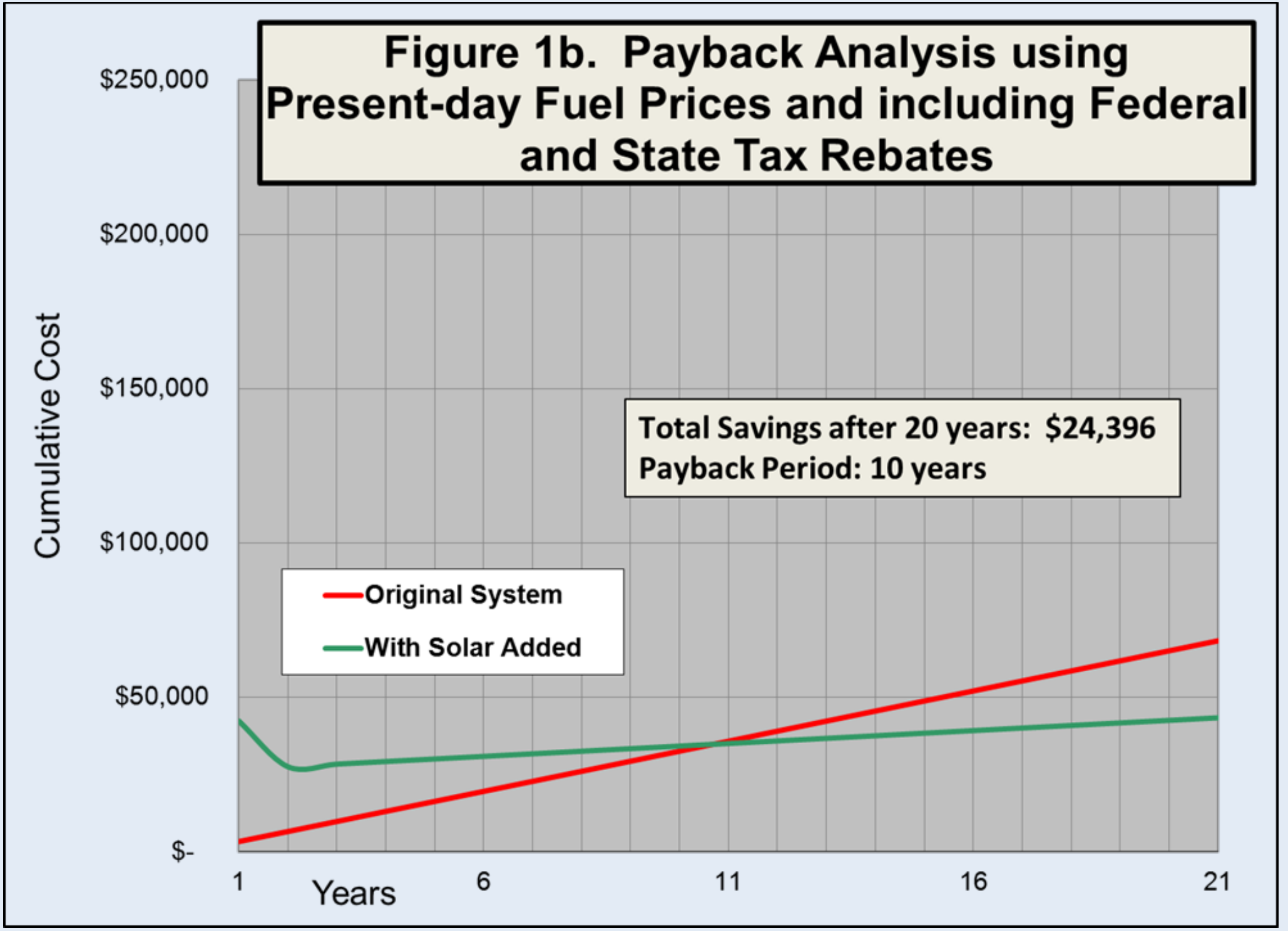


Figure 1b. Payback Analysis using Present-day Fuel Prices and including Federal and State Tax Rebates
$250,000
$200,000
$150,000
$100,000
$50,000
$-
Cumulative Cost
Total Savings after 20 years: $24,396
Payback Period: 10 years
Original System
With Solar Added
1
6
11
16
21
Years

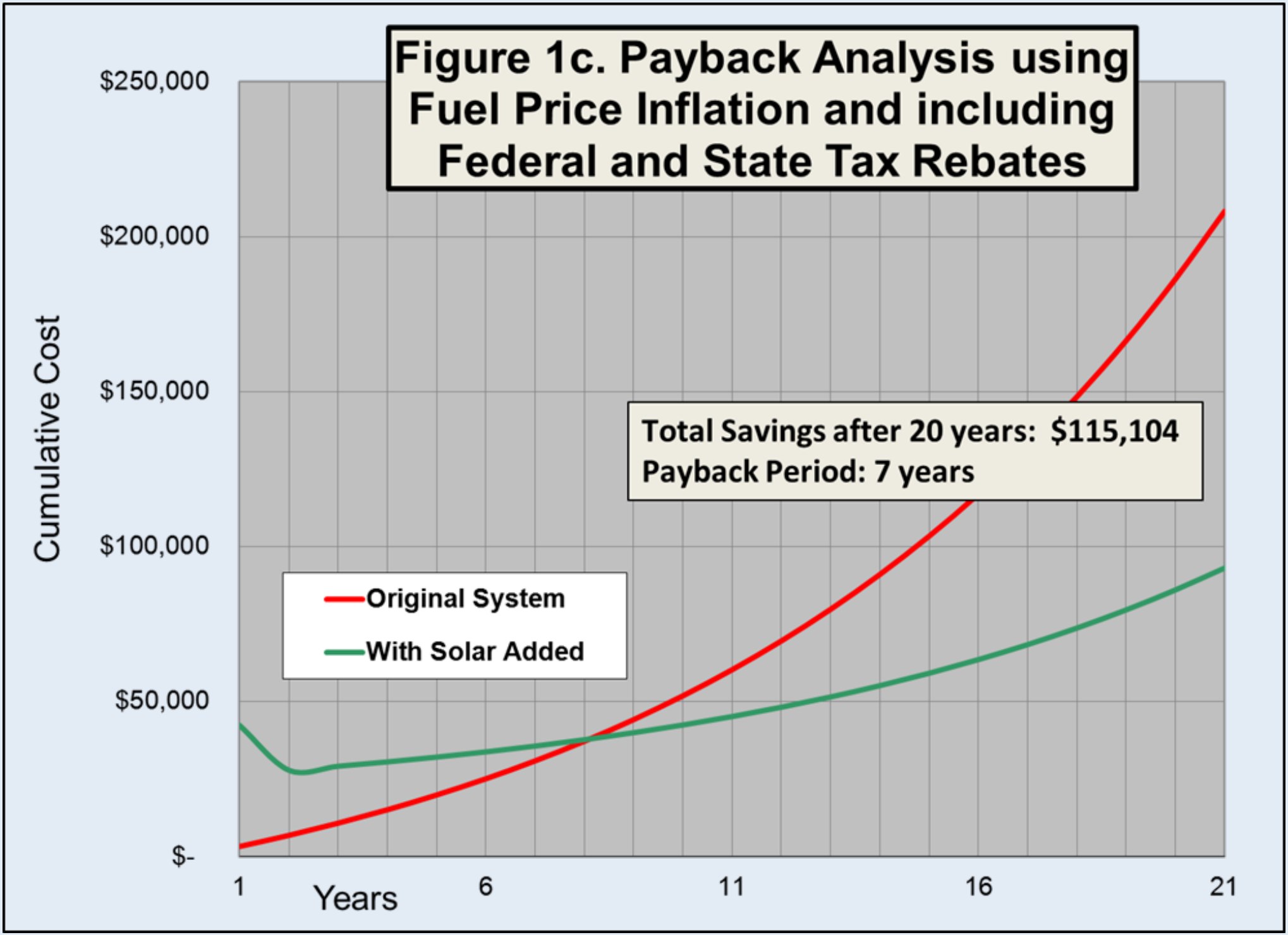


Figure 1c. Payback Analysis using Fuel Price Inflation and including Federal and State Tax Rebates
$250,000
$200,000
$150,000
$100,000
$50,000
$-
Cumulative Cost
1
6
11
16
21
Years
Total Savings after 20 years: $115,104
Payback Period: 7 years
Original System
With Solar Added

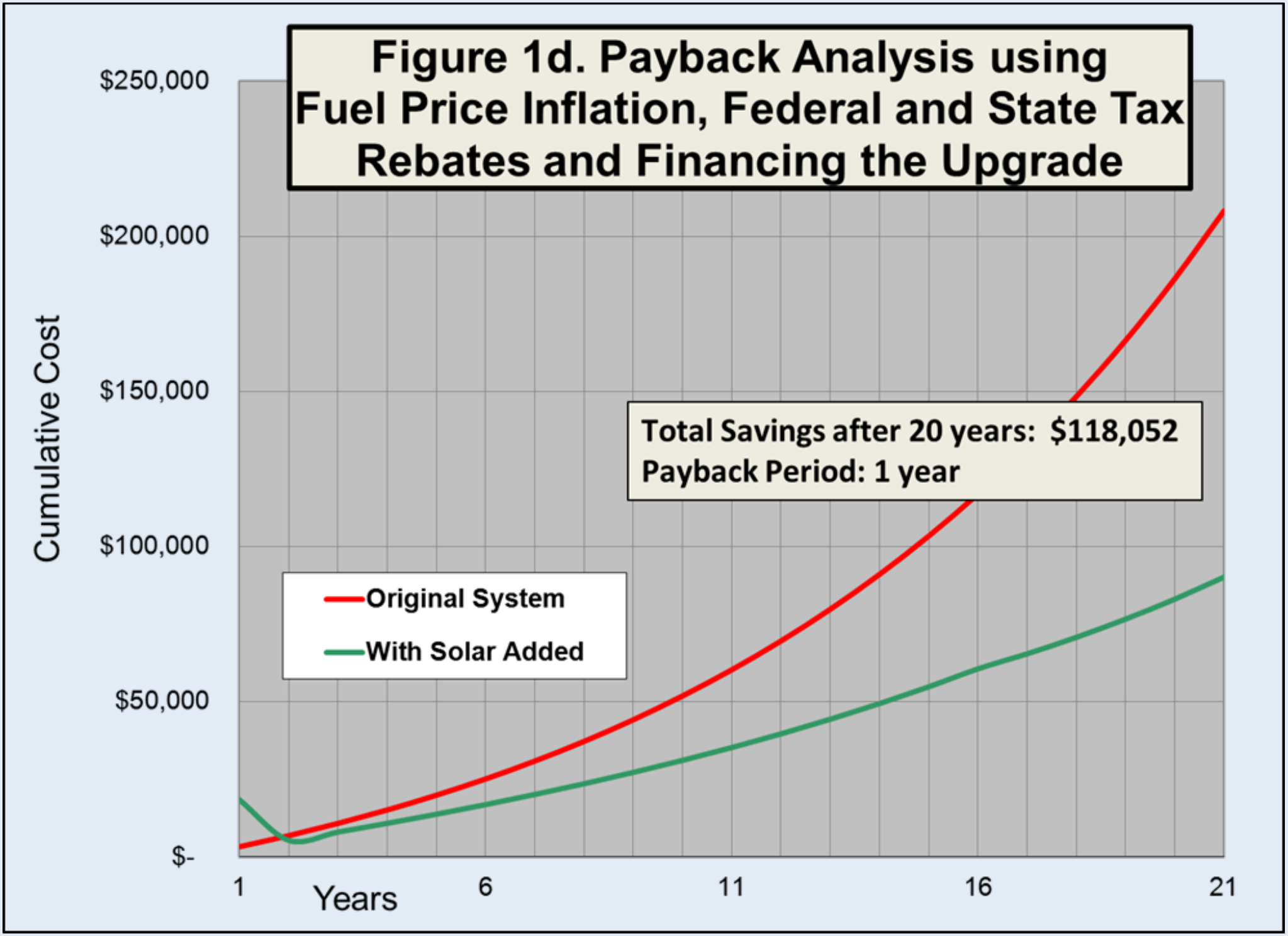


Figure 1d. Payback Analysis using Fuel Price Inflation, Federal and State Tax Rebates and Financing the Upgrade
$250,000
$200,000
$150,000
$100,000
$50,000
$-
Cumulative Cost
1
6
11
16
21
Years
Total Savings after 20 years: $118,052
Payback Period: 1 year
Original System
With Solar Added

Finance Exercise
(Individual)

Take your results from the SLASH-D exercises and put them into the Excel finance model spreadsheet.

1. Try different backup fuels
2. Try different baseline fuel prices
3. Try different loan scenarios

80% of US energy use

is transportation, electricity and heat.

Renewables

are already successfully transforming

two of the three areas.

SOLARLOGIC

Heat &
Hot Water

Transportation

1

Hybrid and
electric vehicles

Electricity

2

PV and
wind power

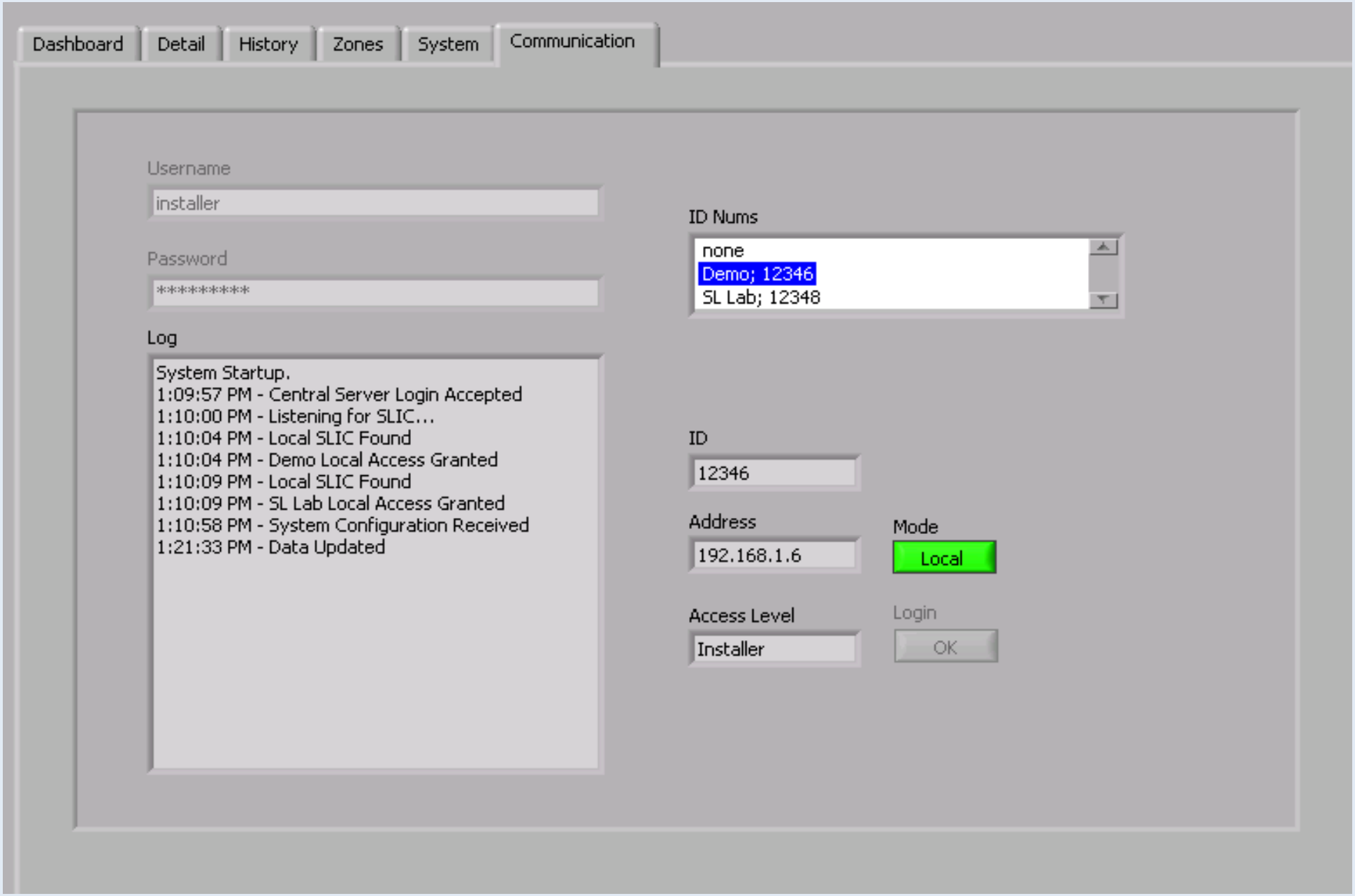
3

The New Solar
Thermal

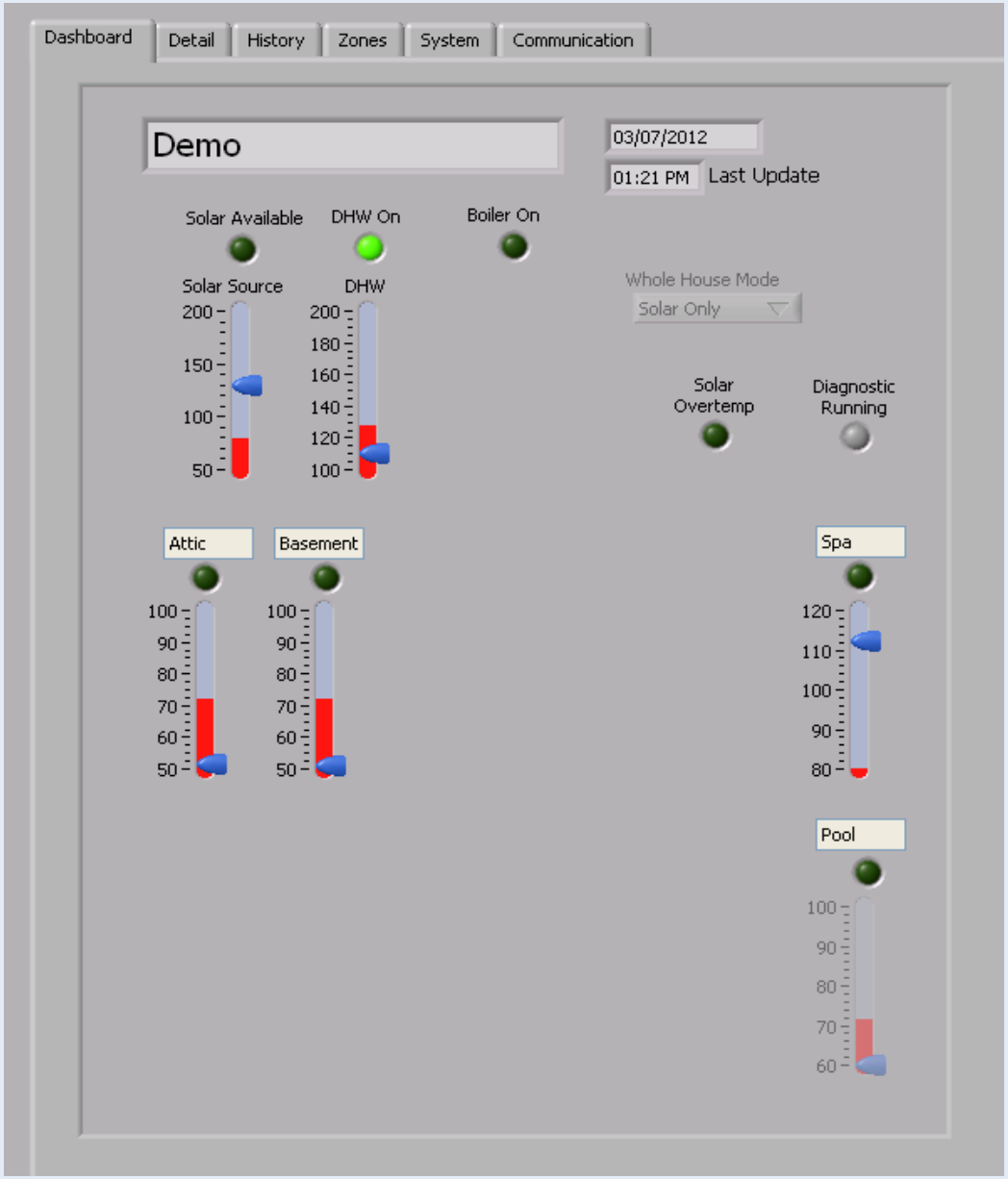
Appendix:
Screen Shots of the VSLIC Tabs

- Dashboard
- Detail
- History
  - Energy Usage
  - Parameter Profiles
  - Log Access
- Zones
  - Indoor Zones
  - Pool/Spa
  - Ice Melt Zones
  - DHW Minimum
  - Setback Groups
  - DHW Recirculator
- System
  - Solar Available
  - DHW
  - Storage
  - Panels
- Communication

Log on at the Communication tab



Dashboard is a top level snapshot of the whole system

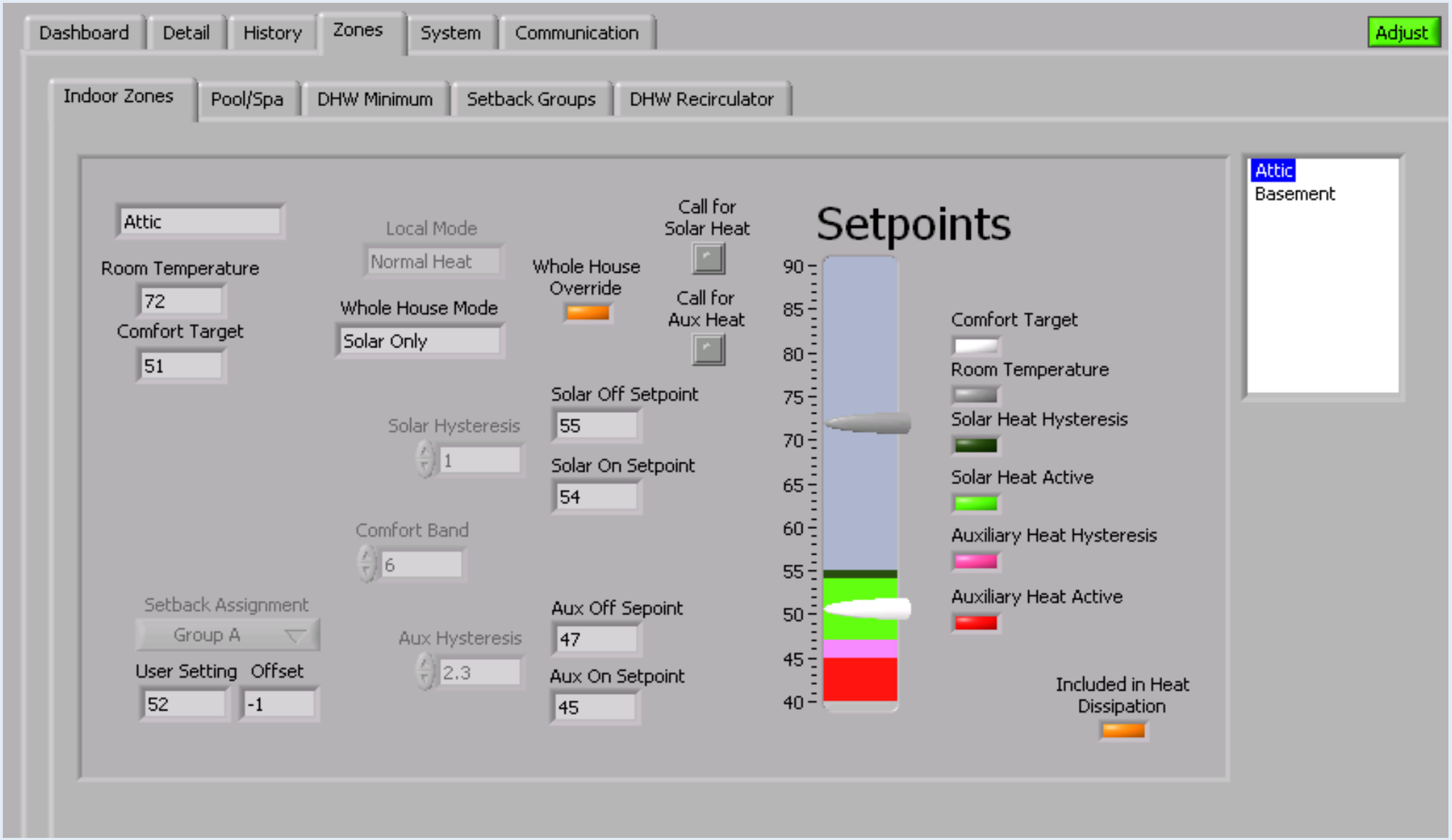


Detail tab shows all pumps, system inputs and valve statuses

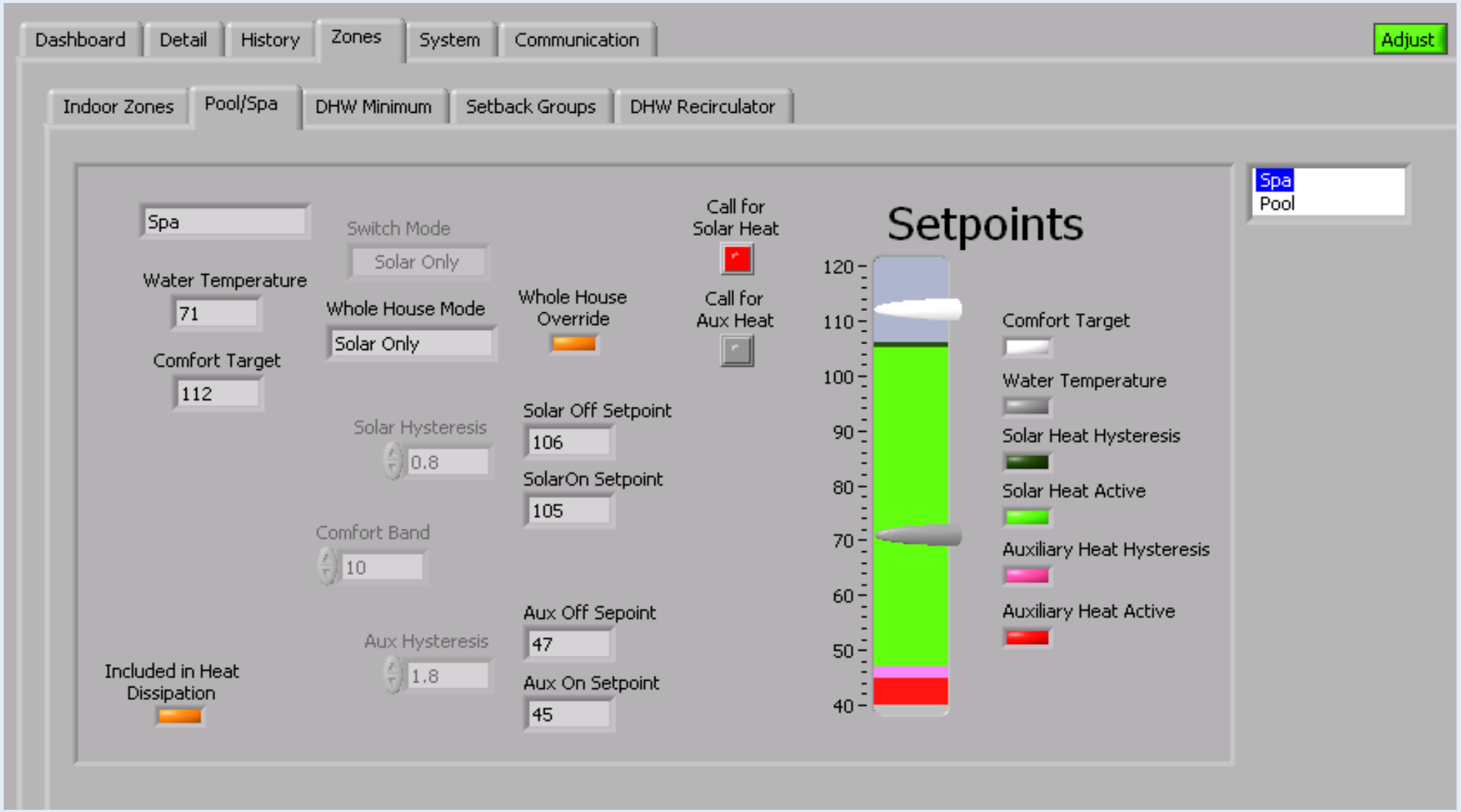
History: Parameter Profiles is for saving, loading and deleting an entire parameter set with two clicks

History: Log Access includes history log data recorded every 5 minutes and a complete history of all parameter changes

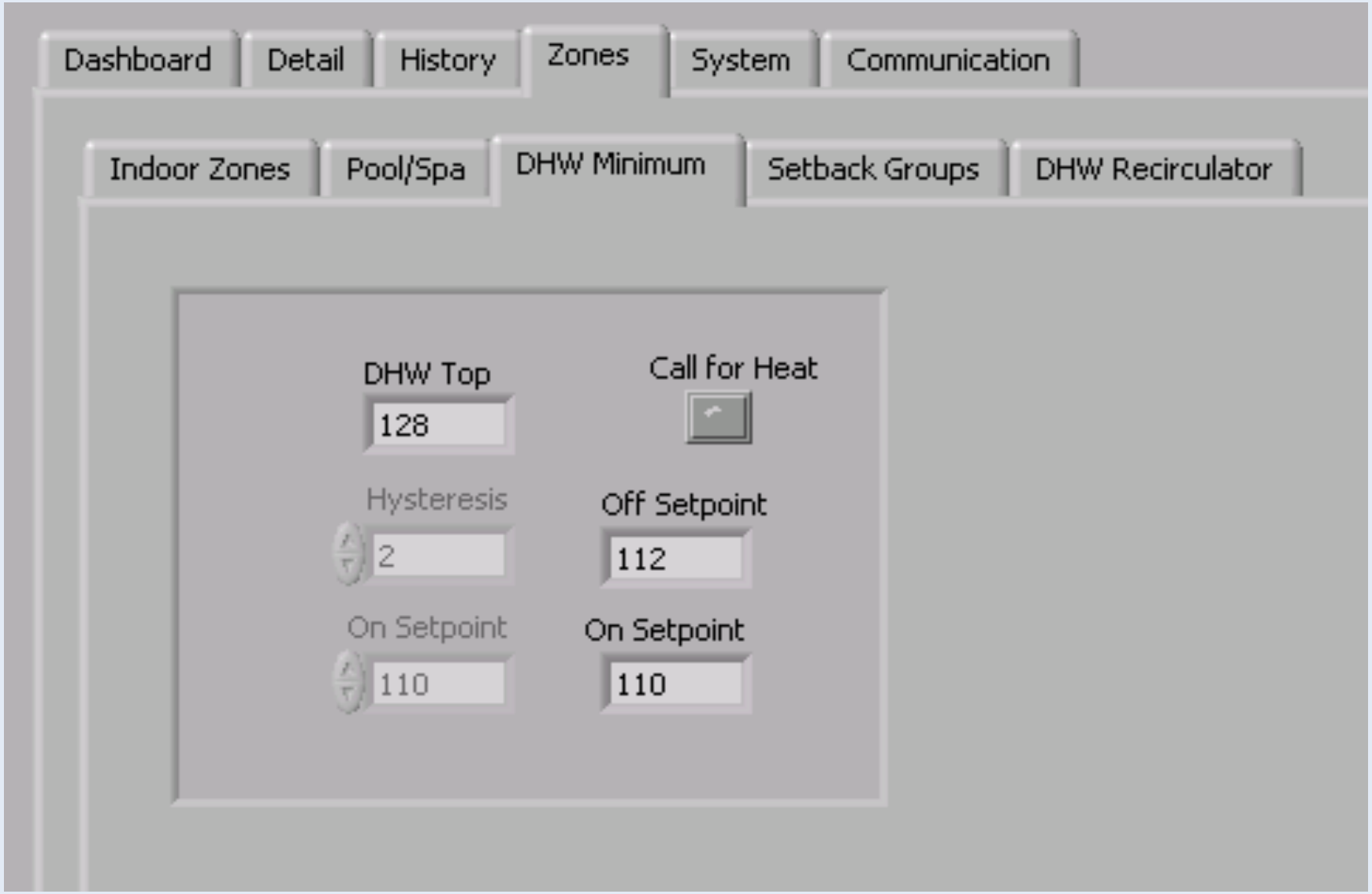
Zones: Indoor Zones shows the complete settings of each zone thermostat



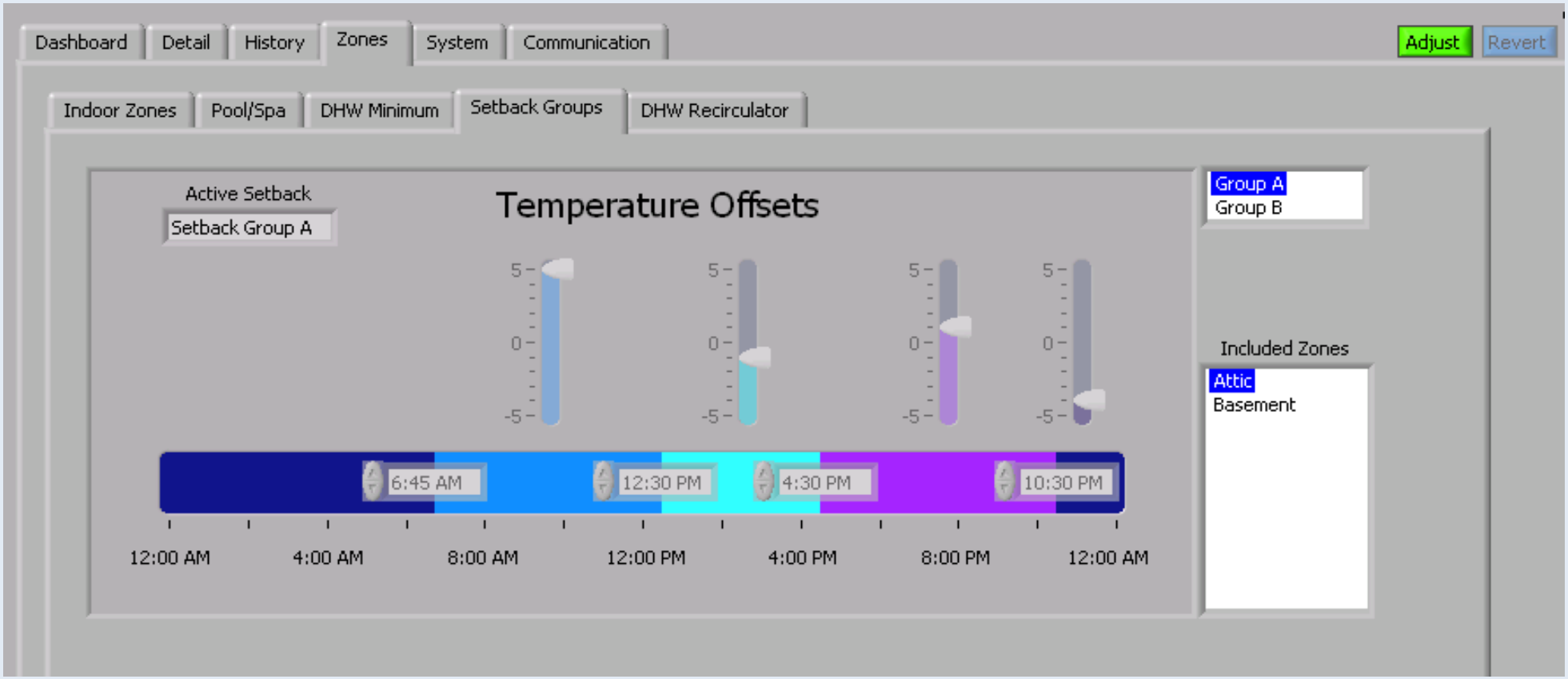
Zones: Pool/Spa functions are very similar to the indoor zones (there are a few exceptions)



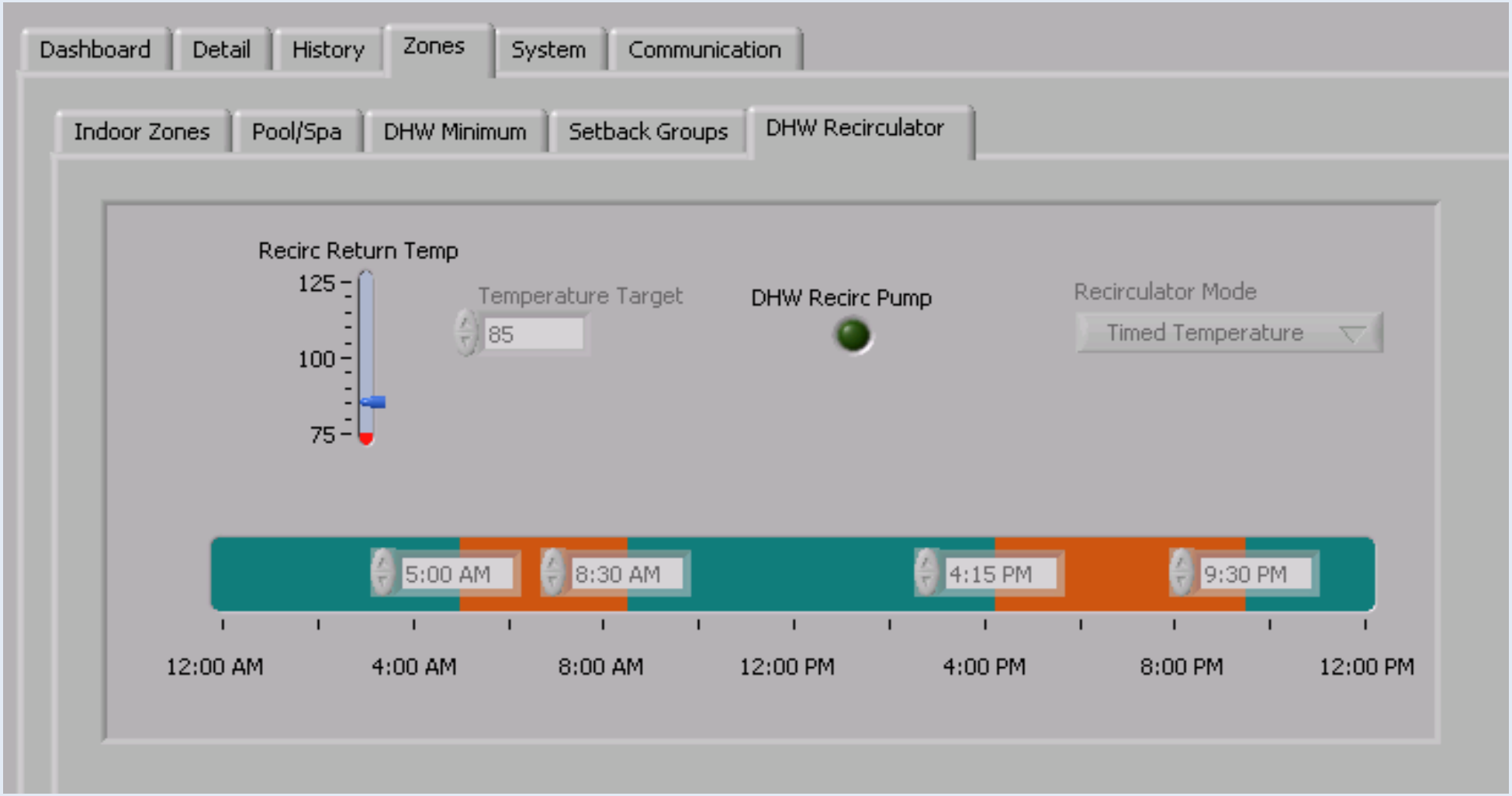
Zones: DHW Minimum is the temperature at which the backup heat will be used to make DHW



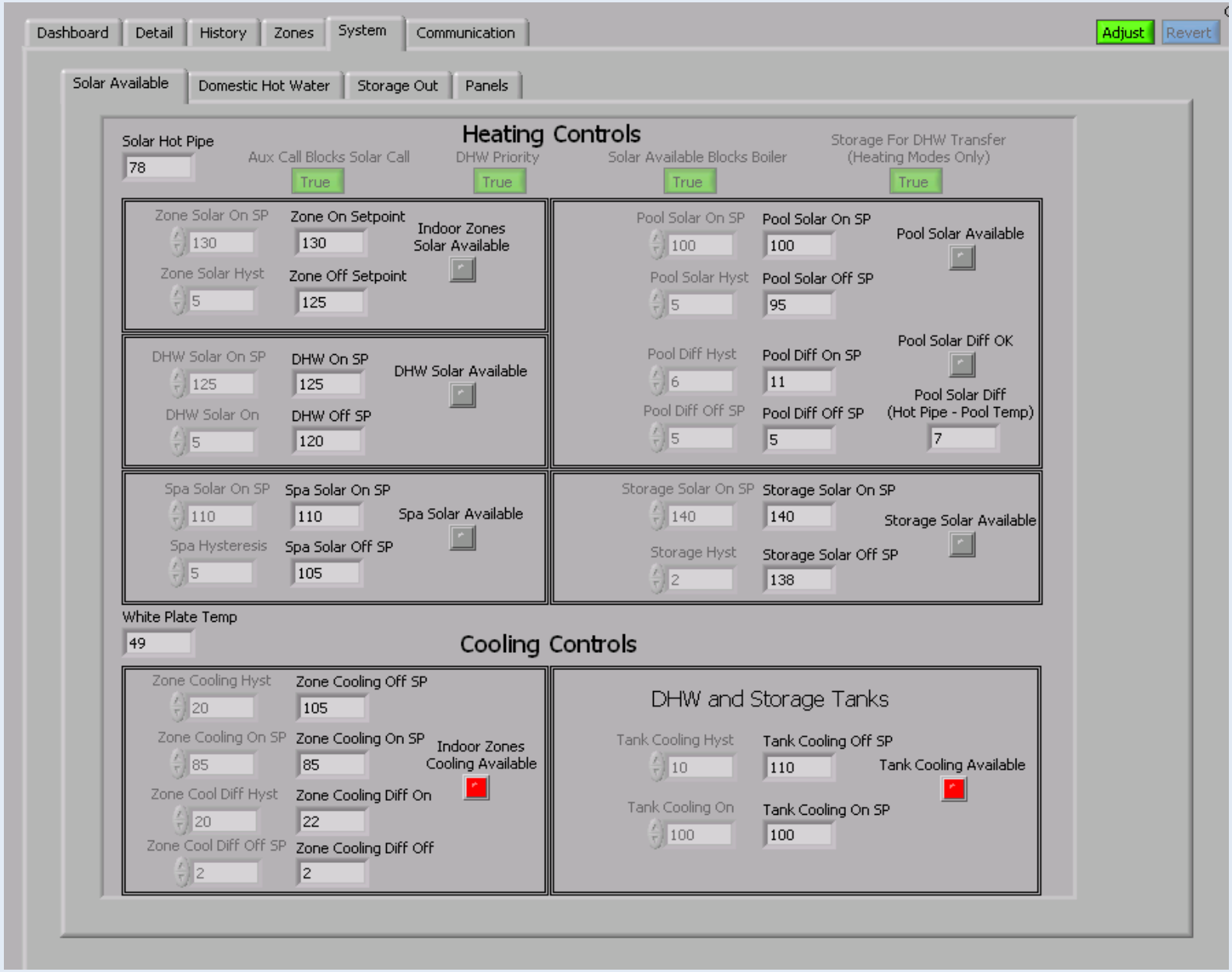
Zones: Setback Groups governs “programmable” thermostats



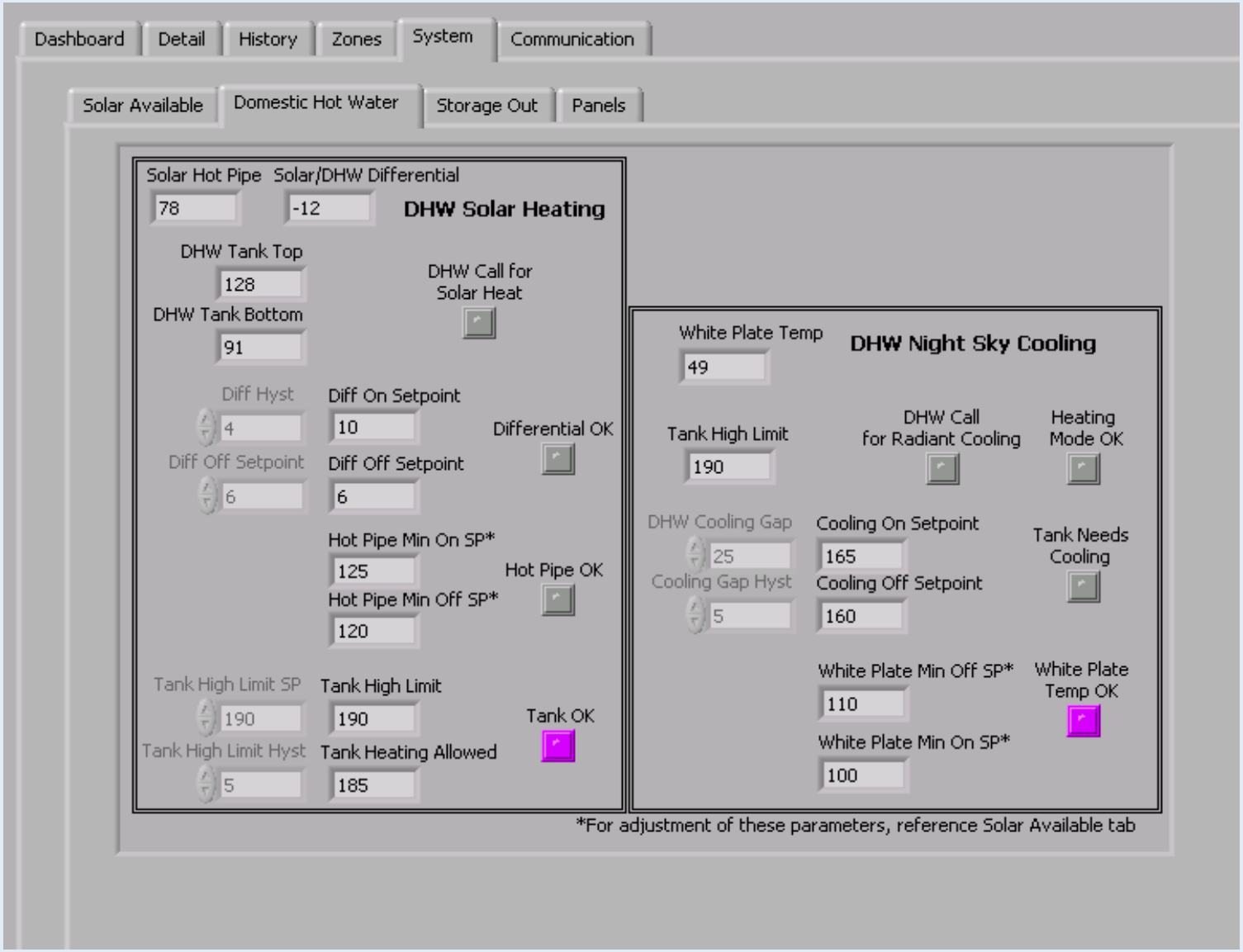
Zones: DHW Recirculator can be set in 5 different modes



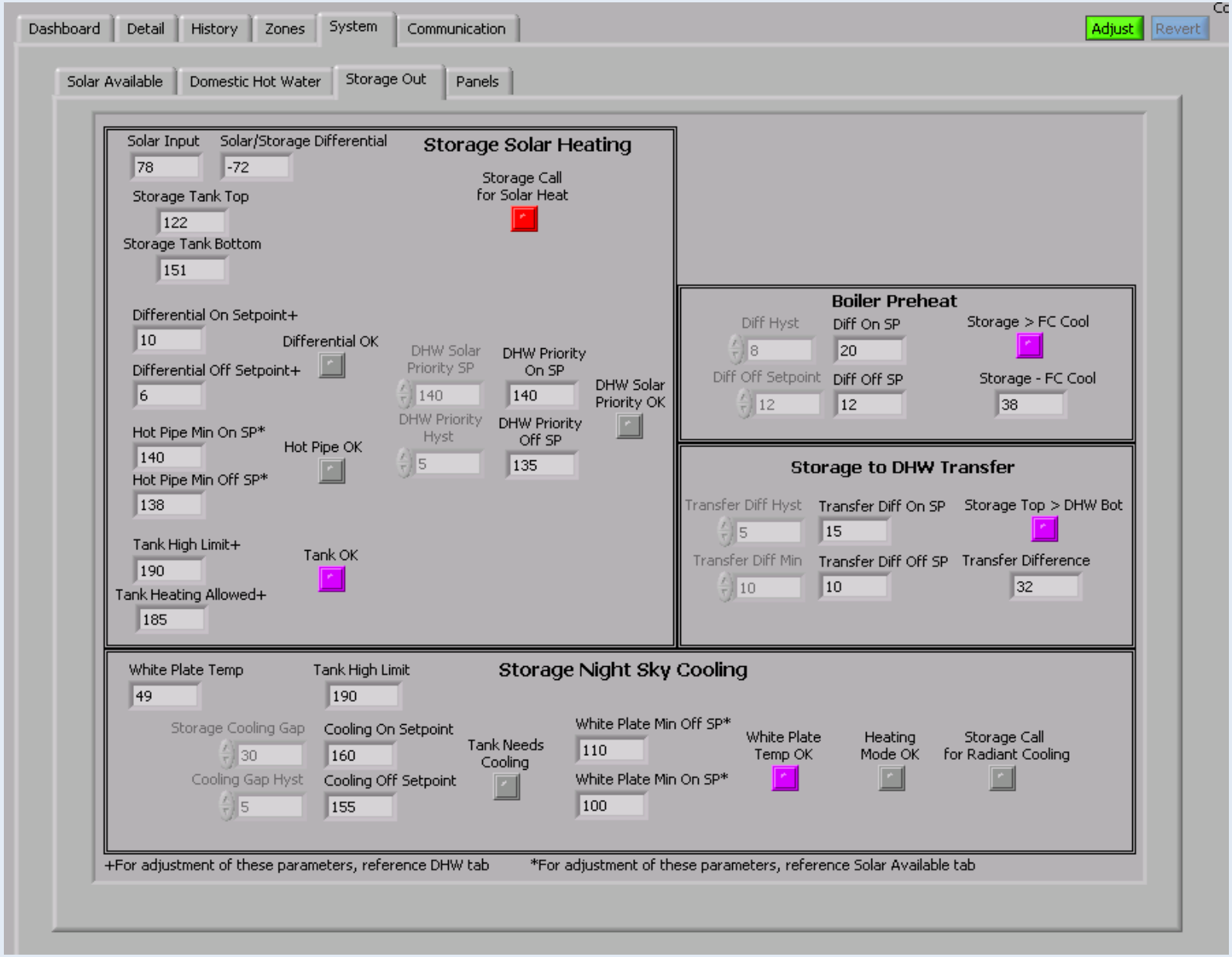
System: Solar Available is all about the heating priorities



System: Domestic Hot Water controls solar heating and night sky cooling of the DHW tank



System: Storage Out controls all functions regarding storing heat and uses of stored heat



System: Panels controls the AC solar collector pumps and overheat protection