

Hawaii Energy Test Lab  
Advisory Group  
Meeting #3  
Draft Presentation Rev F



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# Agenda

- Welcome
- Review of minutes
- HETL Status & Accomplishments
- Test Reports
- Study Reports
- Summary
- Adjourn Meeting

# Housekeeping

- Please silence your cell phone (Maui)
- Bathrooms are behind me (Maui)

# Welcome

Maui Attendees

Oahu Attendees

Big Island Attendees

Kauai Attendees

Florida Solar Energy Center Attendees

Sandia Labs Attendees

HETL Staff

# Mahalo

Maui Community College  
Maui Electric Company, Ltd  
Hawaiian Electric Company  
R&R Solar Supply  
Inter-Island Solar Supply  
Florida Solar Energy Center  
Sandia National Laboratories  
Maui Solar Contractors

# Review of Minutes

- Does anyone have comments on the minutes sent out October 27? They are available on the HETL web site, [www.hawaiirdp.org/hetl](http://www.hawaiirdp.org/hetl), under the Advisory Group section

# HETL Status and Accomplishments

- Obtained funding for personnel
- Activated the lab facility
- Upgraded equipment
- Established the HETL office
- Developed a cadre of personnel
- Developed an intern training program
- Analyzed the performance of 10 solar systems in the field

## HETL Status and Accomplishments, Continued

- Performed investigations
  - T-type check valve performance
  - “Solar” check valve performance
  - Sensor placement
  - Orientation De-rating

# HETL Status and Accomplishments, Testing

- Evaluated & purchased field monitoring equipment (HOBO)
- Created 6 test plans and 6 procedures
- Completed 5 lab tests
- Completed 3 test reports

# HETL Status and Accomplishments, Information Group

- Developed a website
  - <http://www.hawaiirdp.org/hetl/>
- Established an advisors group
- Held two advisors group meetings
- Taught 7 “Take the Mystery out of Solar” introductory classes
- Taught 2 Maintenance/Troubleshooting classes

# HETL Funding Status

- Limited MECO/EPRI funding became available in late 2004
- RDP funding became available October 1, 2005
- EPRI funding ended in early 2006
- MECO funding will provide for testing through the current test
- RDP Intern funding runs through September, 2006
- Income generating activities are being planned
- Further testing will require additional funding

# Investigation Plan Designed to the Survey Priorities (from the previous meeting)

- Lab Setup
  - Determine actual tank capacity (gallons)
    - Complete December 2005
  - Determine hot water storage capacity
    - Complete January 2006
  - Select a Hawaiian draw profile
    - Complete January 2006

# Investigation Plan, continued

- Single Tank Comparison Test
  - Completed
- Comparison with failed check valve
  - Completed
- Find valves to stop fwd siphoning
- Test the best of those valves
- Monitor field installed valves

## Investigation Plan, continued

- Hot water usage vs. family size
  - Completed (presented today)
- Off-orientation computer simulations
  - Completed
- Plan lab modifications for pumped vs. thermosyphon test
  - Completed
- Plan residential & commercial solar monitoring
  - In process

## Tank Capacity Test Report

- Actual tank capacity must be known for BTU computations in later tests
- $\text{BTUs stored} = (\text{temperature increase in degrees F}) \times (\text{tank capacity in gallons}) \times 8.33 \text{ lb/gal}$

## Tank Capacity Test Report

- Three Ruud Solar tanks were filled using a flow meter
- They were an average of 9% smaller than stated on the label
- Manufacturers are allowed +/- 10% error
- FSEC had similar results with 100 tanks

## Tank Capacity Test Report-Data

	<b>System A Ruud Side Connect Tank</b>	<b>System B Ruud Top Connect Tank</b>	<b>System C Ruud Side Connect Tank</b>
<b>Tank Capacity</b>	<b>72.59 gal.</b>	<b>72.1 gal.</b>	<b>72.7 gal.</b>
<b>Stated capacity</b>	<b>80 gal</b>	<b>80 gal</b>	<b>80 gal</b>
<b>Stated minus measured capacity</b>	<b>7.41 gal.</b>	<b>7.9 gal.</b>	<b>7.3 gal.</b>
<b>Percent difference</b>	<b>9.3%</b>	<b>9.9%</b>	<b>9.1%</b>

## Tank Capacity Test Report-Effect on Design

- Solar tanks will be 9% hotter, or 5 degrees F
- This will contribute to overheating if other factors also make the system hot
- Efficiency will be slightly less due to higher operating temperature

## Hot Water Storage Capacity Report

- This test was run to determine:
  - The amount of usable hot water that a tank will produce
  - The amount of heat left in the tank that will give the solar system a head start the next day

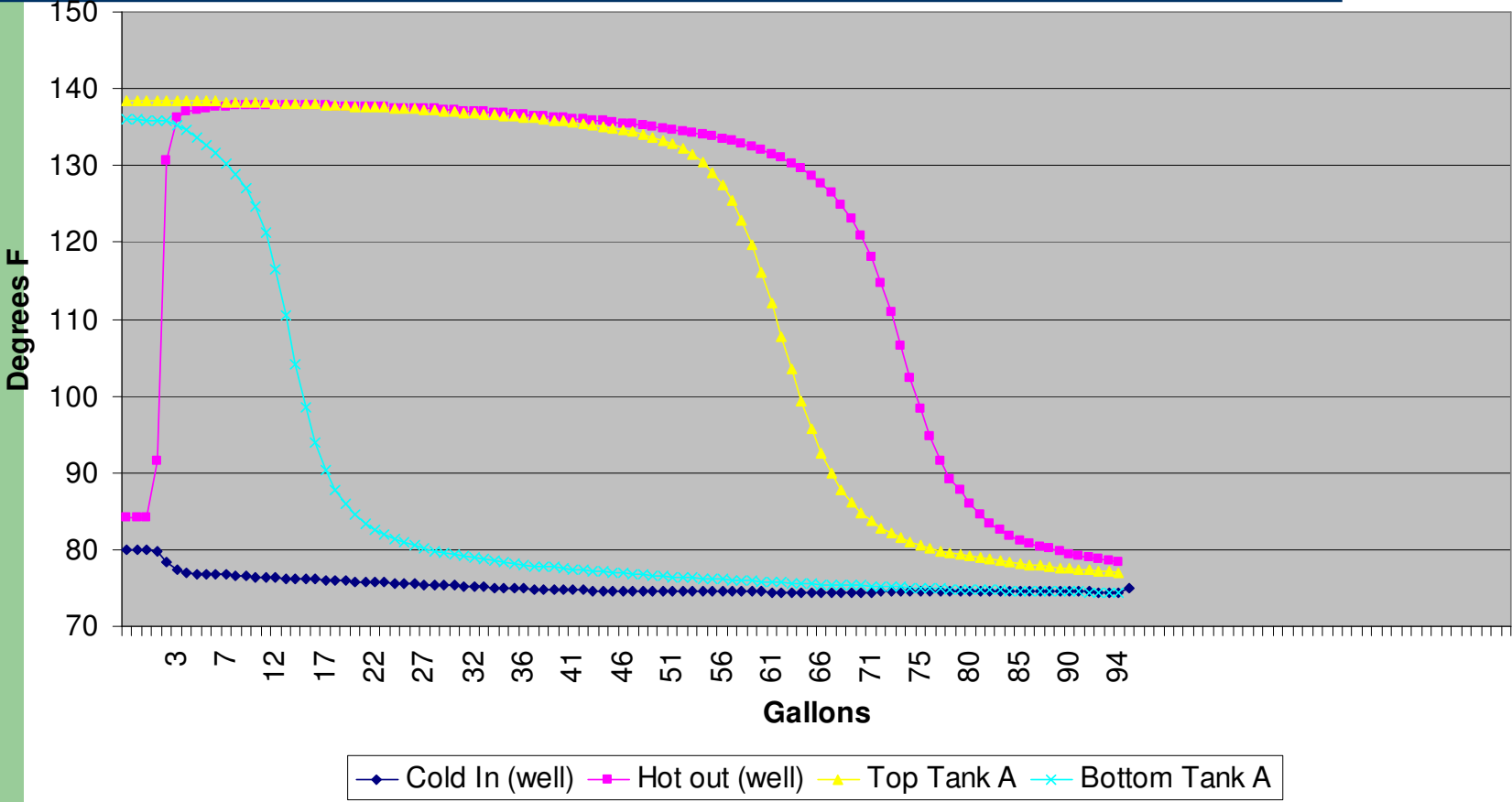
## Hot Water Storage Flow Rate & Temperature

- Maui shower temperature and flow rate data was studied
- A flow rate of 1 GPM was selected for most of the testing.
- Higher flow rates of 1.5 and 2 GPM were also used to measure the flow rate effect
- 100 degrees was picked to be the lowest acceptable shower temperature

## Hot Water Storage – Test

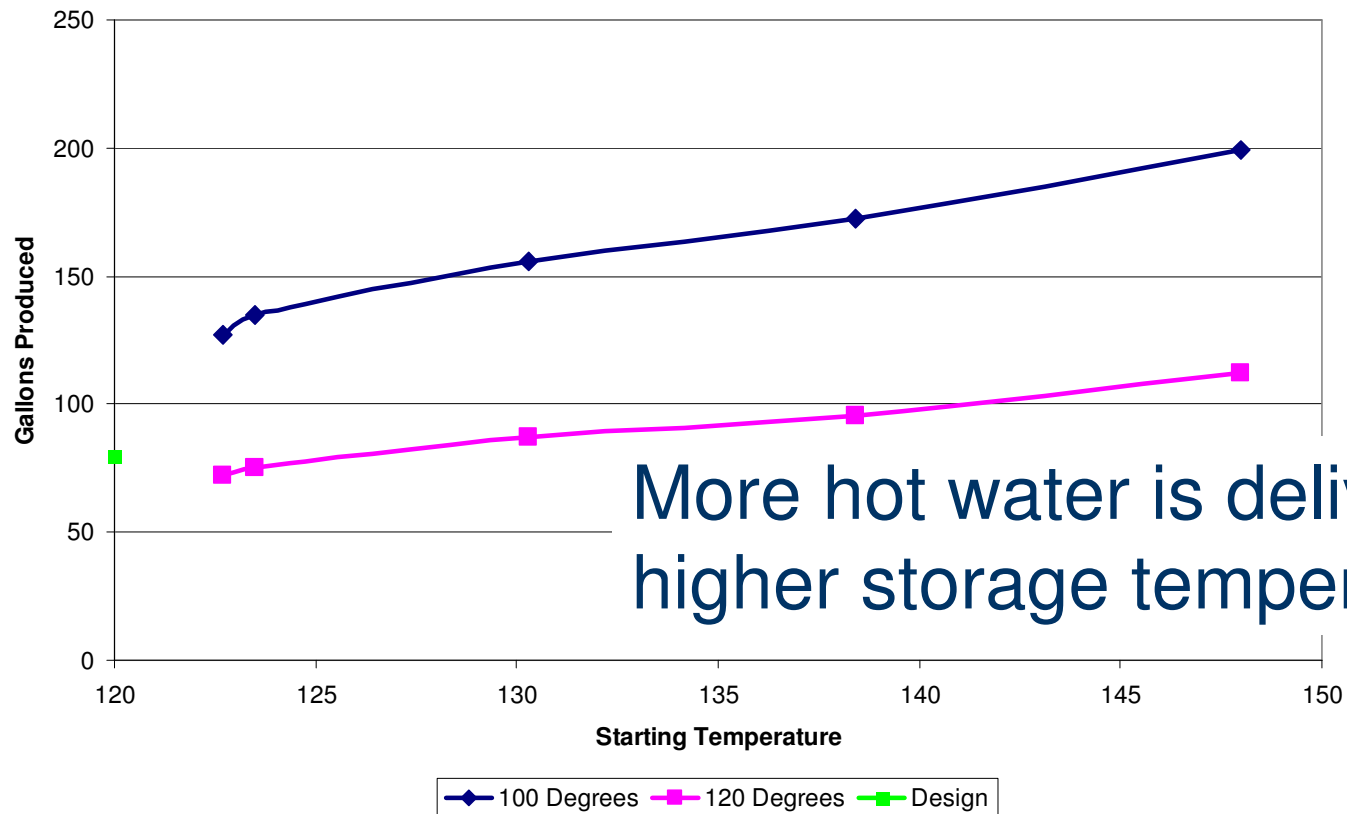
- Water was released at different starting temperatures to determine the BTUs available at various temperatures

# Hot Water Storage – Test Data



# Hot Water Storage – Temperature Effect

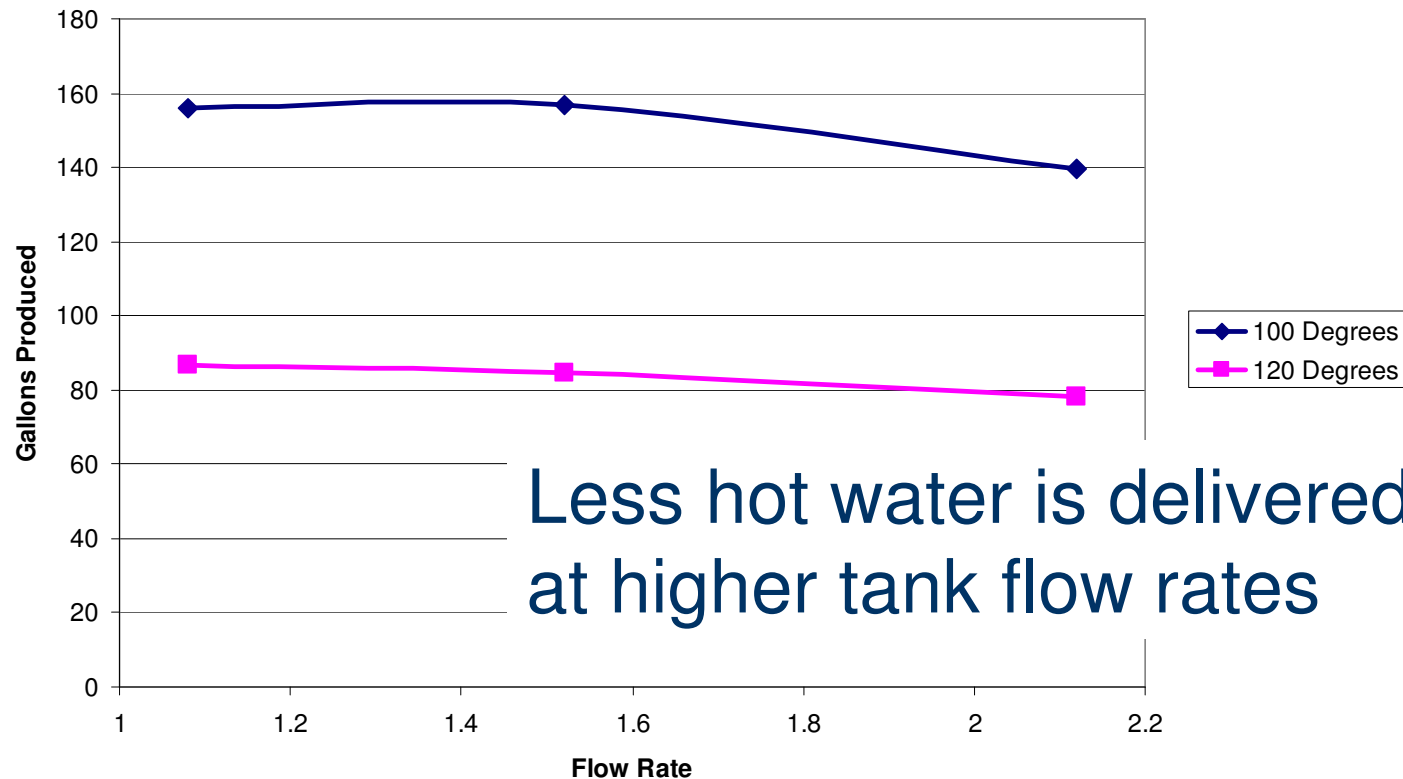
Gallons above 100 Degrees at 1 GPM Flow Rate



More hot water is delivered at higher storage temperatures

# Hot Water Storage – Flow Rate Effect

Gallons above 100 Degrees at different Flow Rates  
130 Degrees Start Temperature



## Hot Water Storage – Residual Heat

- The average tank temperature after all hot water above 100 degrees was used averaged 5 degrees above the cold water temperature
- HECO standards add 5 degrees to the cold water temperature before calculating the solar BTUs needed.
- MECO standards do not, so they will tend to be 5 degrees hotter than HECO systems

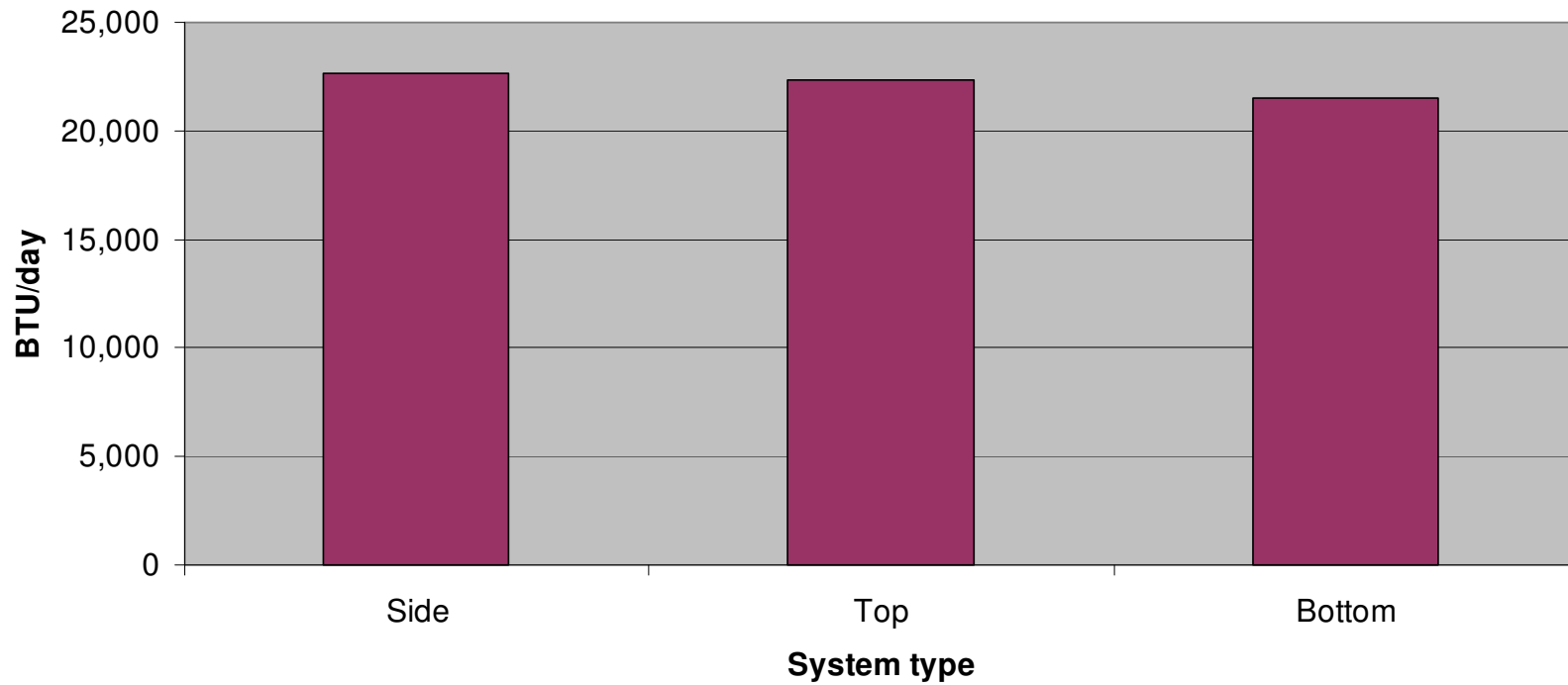
## Single Pumped System Comparison Report

- This test was run to determine:
  - The energy absorbed and lost by the 3 pumped system types: top/side/bottom return
  - Backup power used with normal usage

## Single Pumped System Comparison Test

- Part one of the test (6 days):
  - Release all hot water in the early morning
  - Measure the energy gained from the sun
  - Subtract the energy lost at night
  - Compute Net Energy

# Single Pumped System Test Results

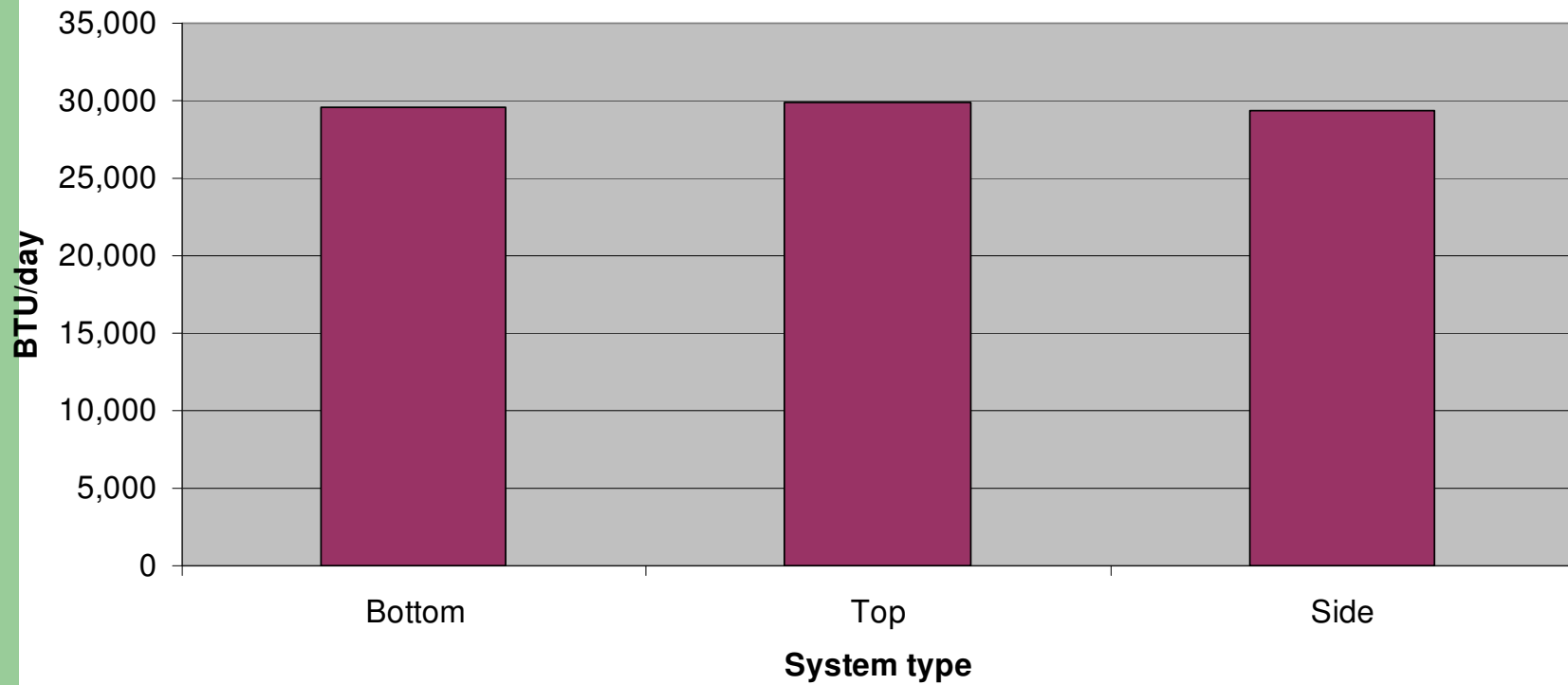


## Single Pumped System Comparison Test

- Part two of the test (4 days):
  - Switch the side and bottom configurations by switching valves
  - Run the same test
  - This checks testing accuracy

# Single Pumped System Test Results

## Switch tank configurations

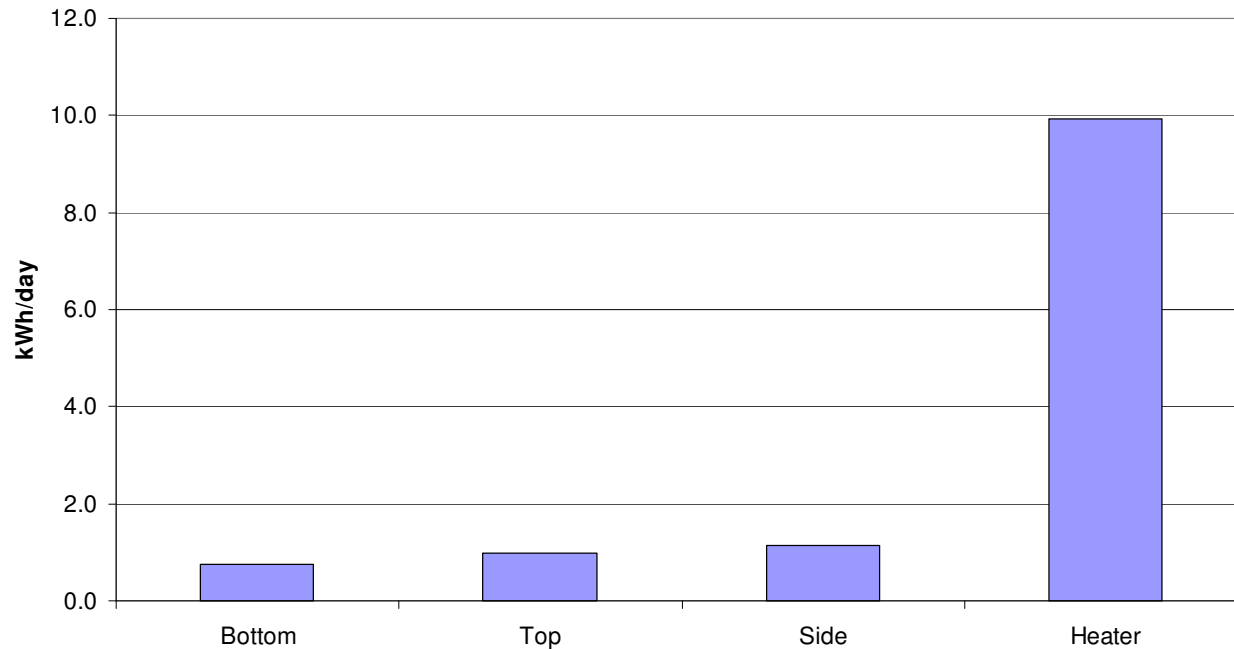


# Single Pumped System Test Results

Type of System	Side	Top	Bottom
Difference from Top Connect	-0.5%	0.0%	-2.3%
System Name	<b>A</b>	<b>B</b>	<b>C</b>
Difference from system B	-0.2%	0.0%	-2.6%

- Performance differences are very small
- Possible errors are the same size as the difference between top & bottom connect performance

# Single Pumped System Test Usage Simulation (8 days)



# Single Pumped System Test Results of Usage Simulation Test

Configuration	Bottom	Top	Side	Heater
Measured kWh/day	0.73	0.94	1.09	9.94
Calculated additional	0.02	0.04	0.04	0.00
Total kWh/day	0.7	1.0	1.1	9.9
Solar Contribution	92%	90%	89%	0%
\$/month at \$.25/kWh	\$6	\$7	\$8	\$75

- Backup power usage differences are small

## Test 5, Check Valve Failure Effects

- Compared systems with a working check valve to those with the check valve bypassed simulating a failure in the open position.
- Usage of a family of four was simulated.
- The backup timer provided power to the backup thermostat/element 4:00 to 5:30 AM & PM
- Water was not released when the top tank temperature was below 100 degrees.

# Test 5, Check Valve Failure Effects

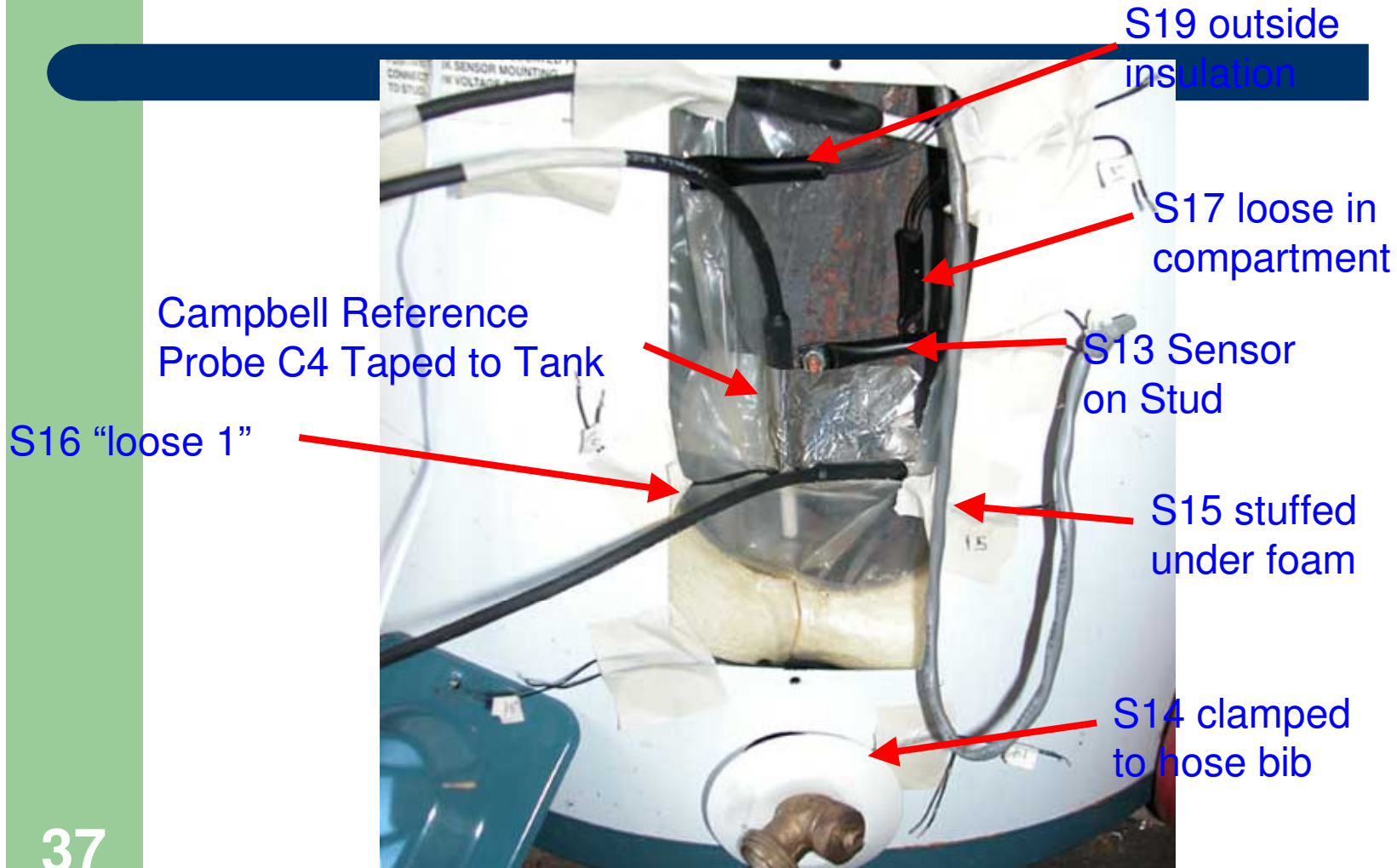
<b>Test 5, Part 1</b>					
<b>Power Saved</b>			<b>Hot Water Production</b>		
<b>Bottom</b>	<b>Top</b>	<b>Bottom</b>	<b>Bottom</b>	<b>Top</b>	<b>Bottom</b>
<b>Bypassed</b>	<b>Bypassed</b>	<b>Working</b>	<b>Bypassed</b>	<b>Bypassed</b>	<b>Working</b>
<b>93%</b>	<b>85%</b>	<b>90%</b>	<b>90%</b>	<b>74%</b>	<b>90%</b>
<b>Test 5, Part 2</b>					
<b>Power Saved</b>			<b>Hot Water Production</b>		
<b>Side</b>	<b>Top</b>	<b>Side</b>	<b>Side</b>	<b>Top</b>	<b>Side</b>
<b>Bypassed</b>	<b>Working</b>	<b>Working</b>	<b>Bypassed</b>	<b>Working</b>	<b>Working</b>
<b>84%</b>	<b>84%</b>	<b>83%</b>	<b>76%</b>	<b>77%</b>	<b>78%</b>

- Top connect produced 16% less hot water and saved 5% to 7% less power.

## Top Connect Tank Sensor Placement Test

- Performed to determine the effect of different tank controller sensor locations on performance
- Sensors were placed at several locations in the sensor compartment and under the pump
- Resistance readings were taken 4 times during the day as the solar system heated the tank

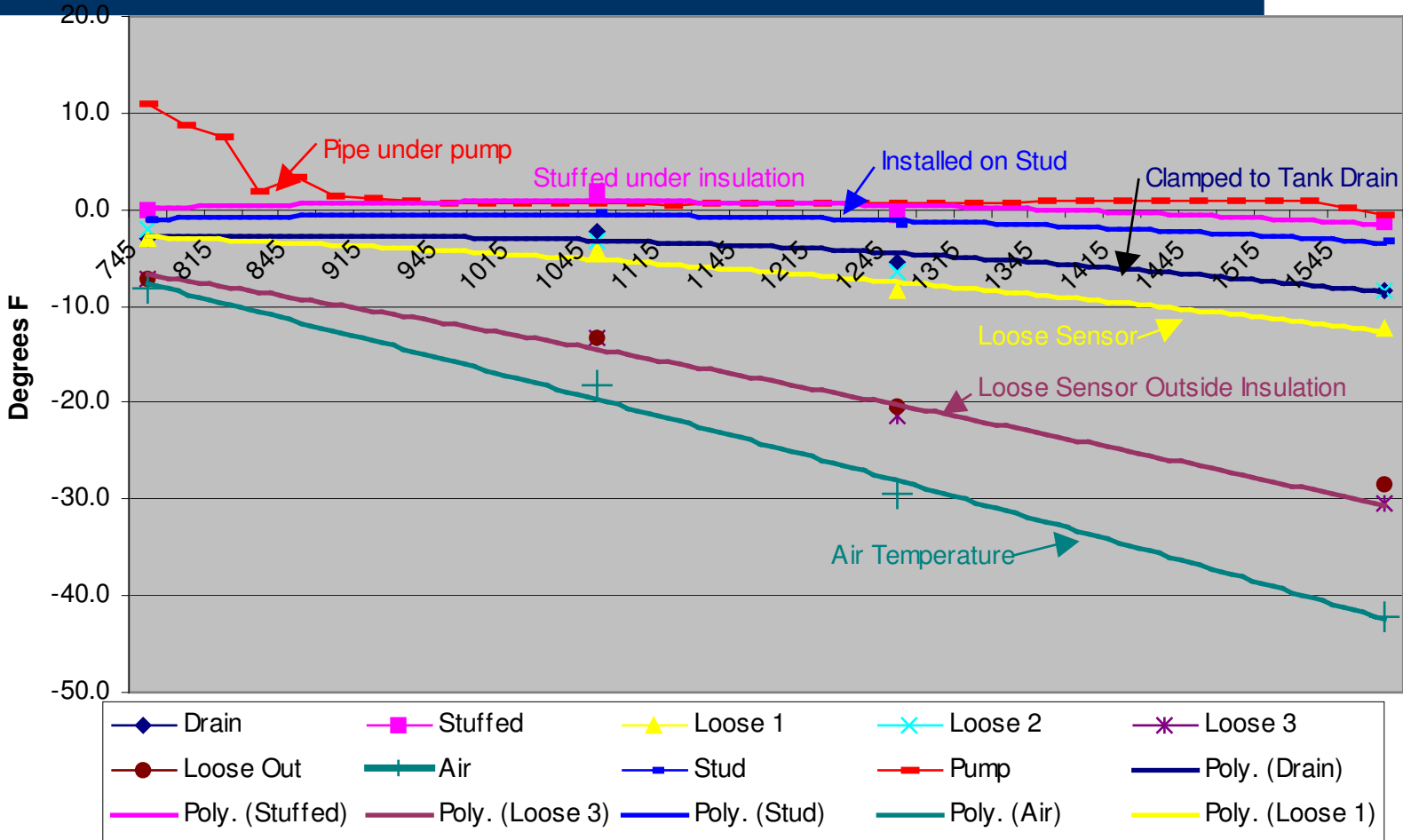
# Sensor Placement



# Sensor Placement – Temperature Differences

SA10 sensor difference from tank temperature

12/19/05



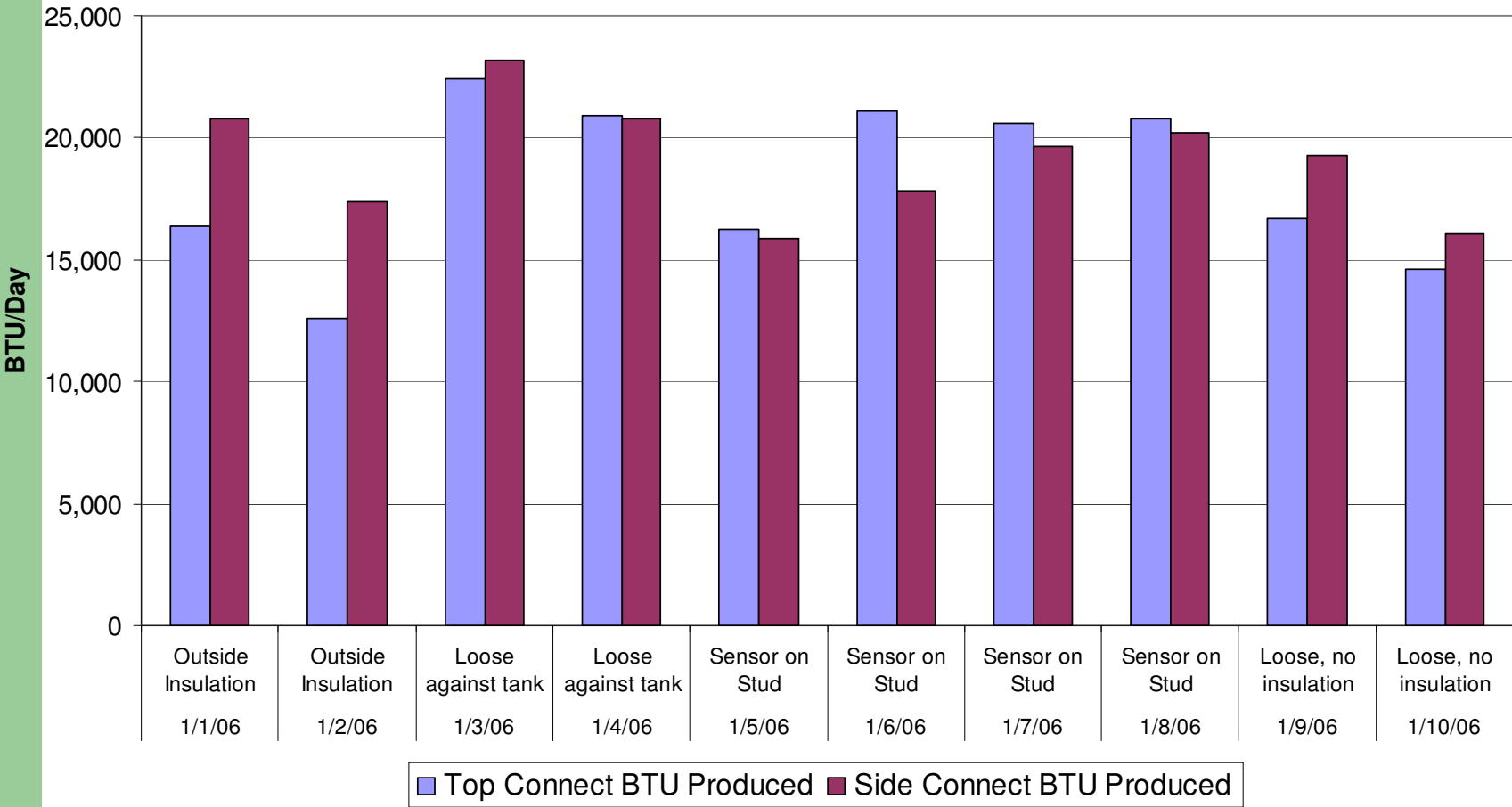
## Sensor Placement Results

- Sensors stuffed under insulation, on the stud, and on the pipe under the pump showed similar readings
- Sensors on the tank drain and loose in the compartment showed lower temperatures, closer to the air temperature

## Sensor Placement Test, Part 2

- Side-by-side testing was performed with the controller sensor in various locations
- A side connect system with the sensor on the stud was the control
- The top connect sensor locations were:
  - On the stud
  - Loose against tank
  - Loose against tank without the removable insulation
  - Loose, outside of the insulation

# Sensor Placement Performance Test Results



## Sensor Placement Performance Test Results

- The top connect/side connect performance bias was removed and performance compared
- A performance loss of 8% was calculated when the sensor was loose against the tank
- The loss was 18% if the removable insulation was missing
- A loose sensor outside the insulation resulted in a 30% performance loss (the pump ran continuously)
- Possible test error was 11%, so differences less than that are not meaningful

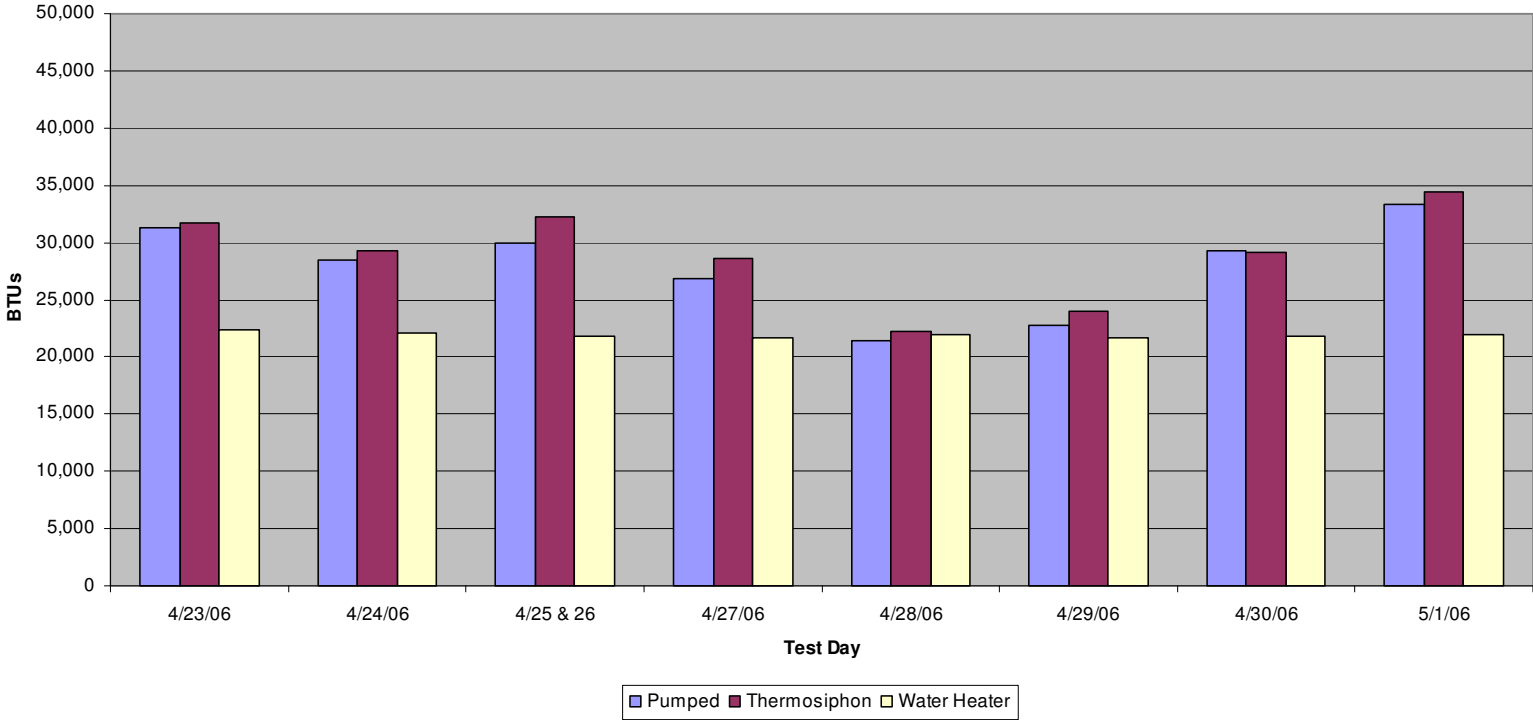
## Sensor Placement Conclusions

- Top connect sensor locations on the stud, stuffed under the insulation, and clamped to the feed pipe under the pump have similar performance
- If the sensor is stuffed under the insulation, falls out, and remains under the insulation, performance is reduced slightly if the removable insulation is in place
- If it falls outside of the insulation, major performance degradation takes place
- If anything else causes the pump to run all the time, the result would be a 30% reduction in performance

# Test 7

## Pumped/Thermosiphon Comparison

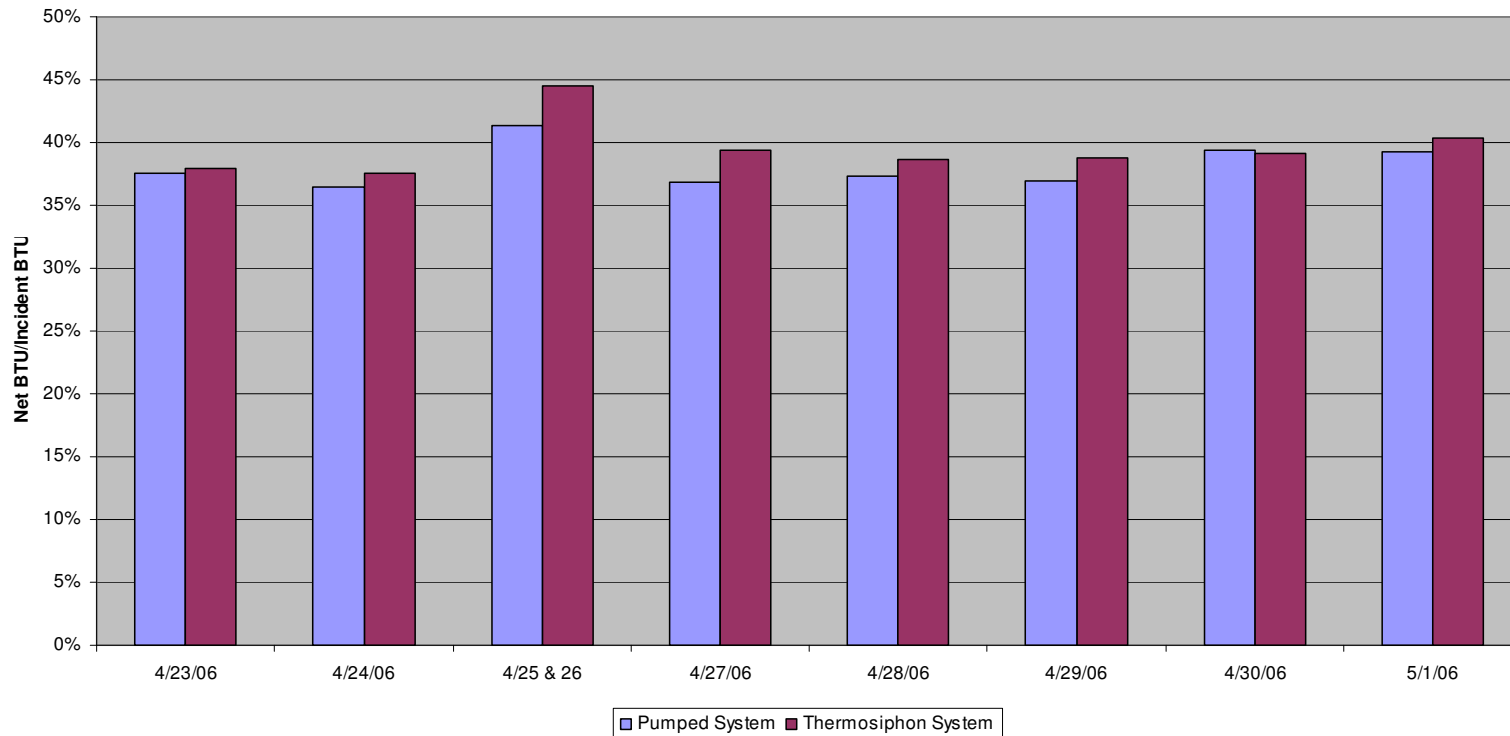
Single Tank Comparison  
Net BTUs



# Test 7

## Pumped/Thermosiphon Comparison

Test 7-3 Net System Efficiency



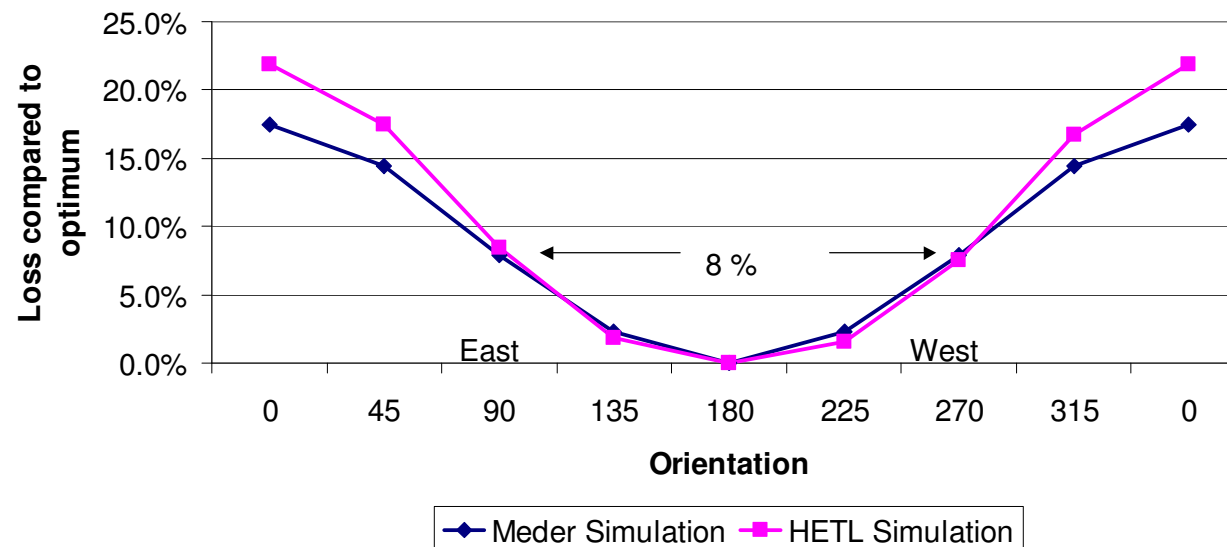
## Off-Orientation De-rating Update

- Simulation results presented at the last meeting showed that yearly loss due to pointing collectors due East or West was 8%, while utility standards require 20% to 25% de-rating for due west or east orientations.
- The increase in winter/summer difference was 20%
- Similar results were obtained with a PV simulation program, but verification was needed by an independent group.
- Steve Meder of UH studied solar insolation at various orientations for HECO.

## Off-Orientation Verification

- The UH study showed the same results except for collectors facing North

HETL/Meder simulation comparison  
20 degrees tilt



## Off-Orientation Verification

- The HETL simulation used SolarPro which reports energy savings compared to an electric water heater each month of the year.
- Steve Meder reported the average yearly energy absorbed from the sun.
- Good correlation with such different methods is encouraging.

## De-rating Reduction Advantages

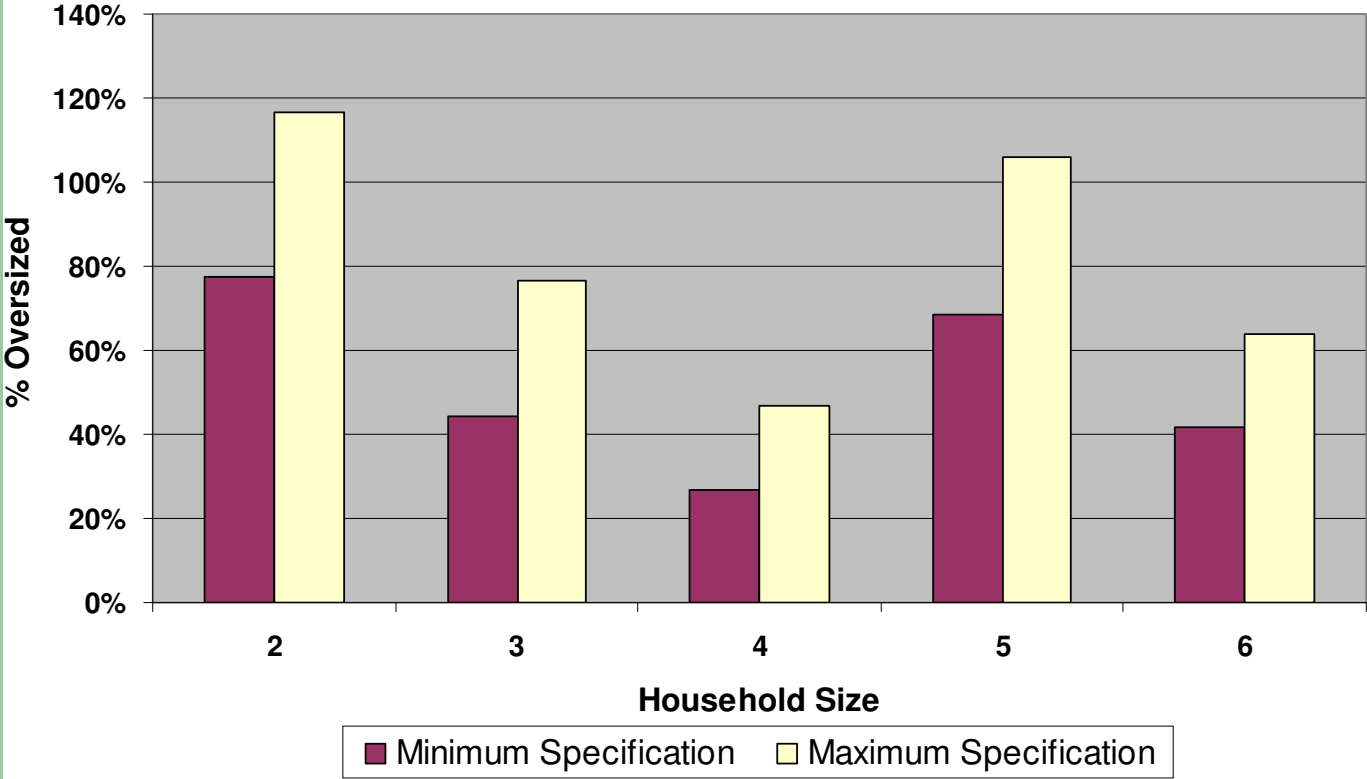
- Less requirement for tilting the collectors south.
- Less summer overheating when de-rating is applied instead of tilting the collectors.

## System Sizing Variation

- Daily hot water usage was calculated by family size from water heater power usage measurements
- This was compared to MECO system sizing requirements

# Maui System Sizing Variation

Maui System Size: Measured vs. Required



## Causes of Overheating

- Minimum system size requirement creates oversizing for family sizes less than 4 40-120%
- Larger families use less than 20 gallons per person 22-105%
- Actual tank size is 9% smaller than stated which contributes to overheating 9%
- 10% of heat is left in the tank overnight, giving the system a head start the next day (Maui only) 10%
- Off orientation de-rating of collectors 5-25%

## Benefits of a Hot Design

- Customers and utilities save more power
- Higher temperatures kill bacteria
- Inefficiencies such as check valve failures are not as noticeable
- Customers have fewer complaints

## The Downside of a Hot Design

- Potential for scalding
- Slightly higher installation cost
- Tanks and collectors corrode faster at temperatures over 150 degrees F

## Options: Where to go from here

- Raise MECO starting temperature by 5 degrees which would reduce collector sizes by 10%
- **Keep them the same and test cooling methods**

## Ways to Cool Down the Systems

- Controller high limit that turns pump off
- Automatically turn pump on to control temperature
- Large tank (150% of daily usage)
- Mixing valve
- Does anyone have other ideas?

## HETL Testing Options

- **Test cooling methods**
- **Investigate off-orientation performance**
- Investigate check valves
- Other suggestions?

## Possible Organizational Changes

- Expand Advisory Group to a statewide chartered advisory committee
- Committee could commission testing and investigations by HETL and other organizations
- Scope of the committee could be Solar Hot Water or all alternative energy and energy conservation

# Adjourn

- Mahalo for attending!
- Next meeting September 2006
- Minutes will be available on the website