Solar Weatherization Assistance Program (SWAP)

Reducing Low Income Energy Costs

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Cocoa, Fl

WHAT WAS SWAP?

- Solar Weatherization Assistance Program
- Funded by U.S. Dept. of Energy and Florida Dept. of Community Affairs
- Pilot program to install solar water heating systems on low-income housing

WHAT WAS SWAP?

- Integrate the use of solar systems in the Fla. Weatherization Assistance Program (WAP)
- Increase installation of solar systems in Florida to reduce low-income clients utility bills
- To determine performance of solar systems installed on low-income housing
- Evaluate the impact of solar systems on low-income housing

WHY HAVE A SWAP PROGRAM?

- Create a niche market for low-cost solar water heating systems
- Investigate retrofit measures that may have more impact on energy use reduction

WHO PARTICIPATED IN THE SWAP PROGRAM?

- U.S. Dept. of Energy
- Florida Department of Community Affairs
- Local Weatherization Assistance Program agencies
- Florida Solar Energy Center
- Florida solar industry
- Low-income clients

WHERE DID SWAP TAKE PLACE?

- Various WAP agencies throughout Florida
  - North
  - Central
  - South

What did we accomplish?

- Over 800 low-cost solar water heating systems installed
- Conducted detailed instrumented monitoring on 35 (32) systems through Florida
  - different types of systems
  - North, Central, South Florida
- Conducted utility bill analysis
- Conducted surveys of system owners
- Conducted inspections of over 25% of installed systems
- Provided evaluation of overall program
- Developed procedures for implementing similar program

SWAP Installed Systems

Florida Location	Agency	System	Total installed Systems	Average System Cost
North	Central	ICS	45	$1,641
	Suwannee	ICS	90	$1,631
	Suwannee	Pumped	1	$1,690
	Tri-County	ICS	48	$1,641
Central	Citrus	ICS	25	$1,516
	Citrus	Pumped	4	$1,388
	Citrus	Thermo	1	$1,690
	Mid-Florida	ICS	162	$1,497
	Mid-Florida	Pumped	28	$1,384
	Pinellas	Pumped	5	$1,535
	Pinellas	Thermo	1	$1,750
South	Metro-Dade	Pumped	307	$1,501
	Centro	ICS	4	$1,540
	Centro	Pumped	30	$1,423
	Lee County	ICS	19	$1,641
	Lee County	Pumped	31	$1,414
		Total Installed Systems	801	
			Average Cost	$1,555

SWAP PROGRAM

DEVELOPMENT
AND
IMPLEMENTATION PROCESS

Program Development and Implementation

- What we did in Florida
- FSEC involved in all phases of development and implementation of program
- Steps that you can replicate for a successful program

Program Development

- Program guidelines
- Client qualifications and residence selection
- System and technical guidelines
- Contractor requirements
- Pre and post solar system inspections
- Training
- Monitoring/Performance Validation

Program guidelines

- Guidelines will determine success of program
- Develop thorough guidelines that will be used as reference during program implementation
- Develop consensus on all requirements and specifications by all participating parties before program is implemented

Client Qualifications

- Florida followed basic Weatherization Assistance Program economic qualifications
- Required a minimum of 3 persons per residence
  - 60 gallons plus per day (finding)
  - LIHEAP, high energy users
- Owner occupied, detached single-family homes

Residence Selection

- Pre-solar site inspection of residence
  - Solar access inspection
  - Roof inspection
  - Water heater inspection
  - Electrical inspection
  - Plumbing inspection
  - Occupant questionnaire

SOLAR ACCESS INSPECTION


Solar Siting
and Analysis


36° N. LATITUDE


36° N LATITUDE
'96 8 6

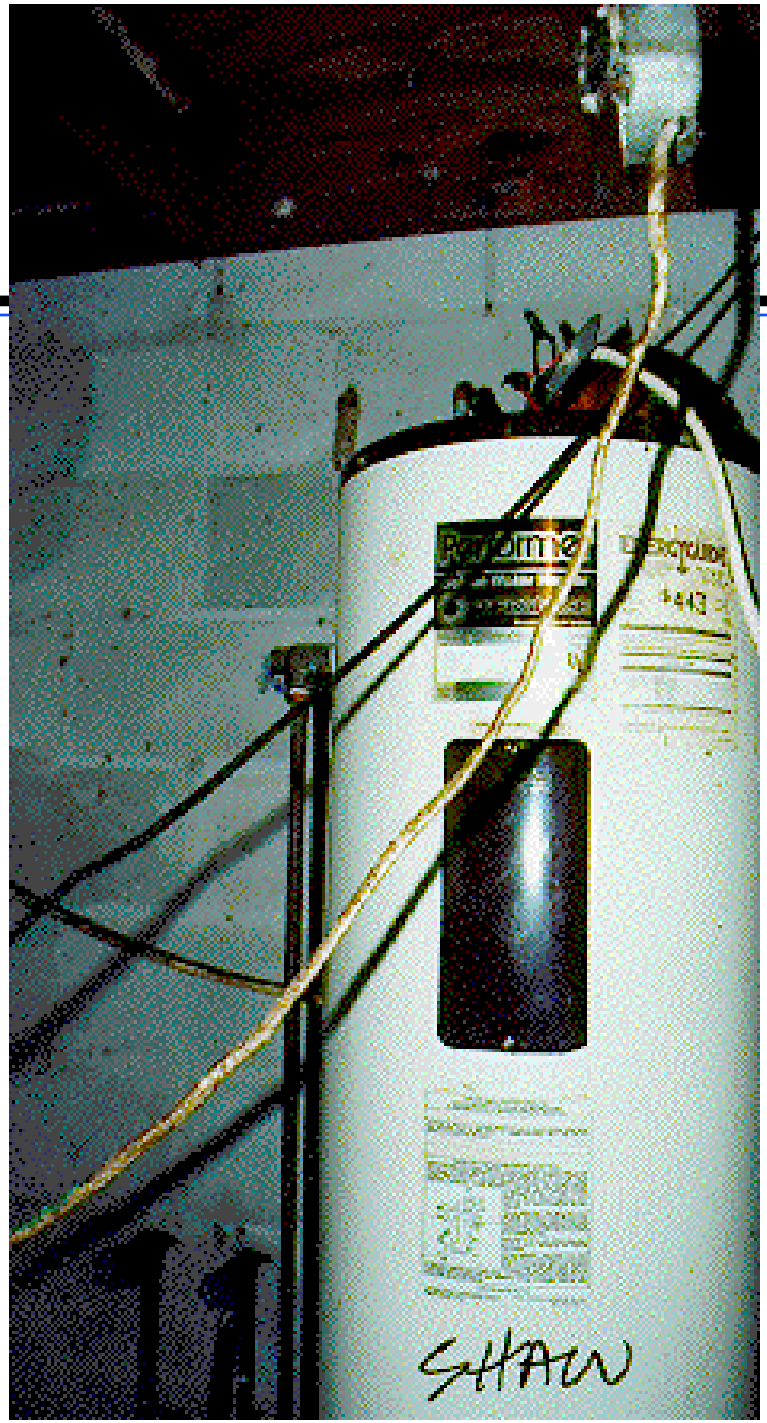

I MEANS

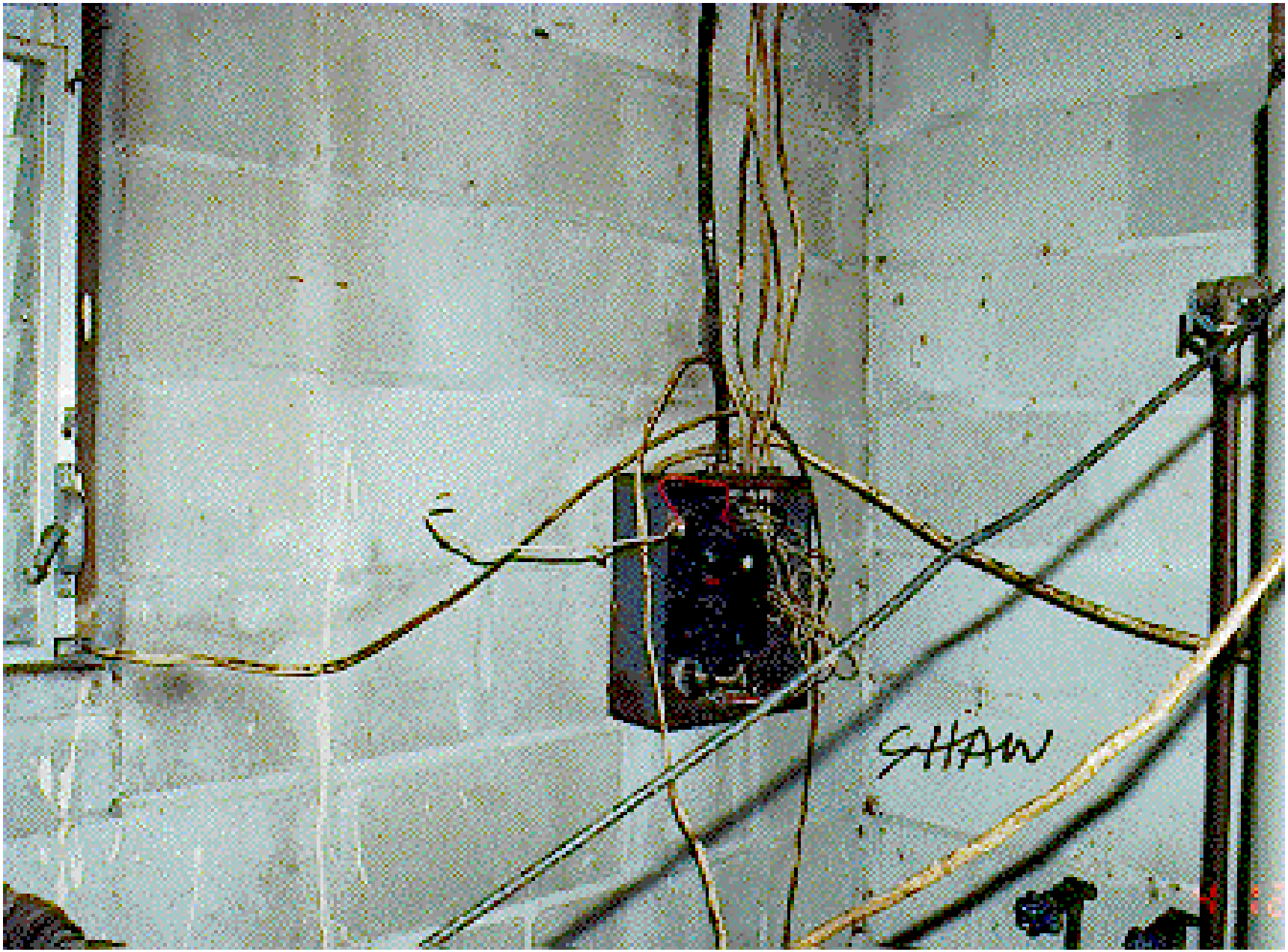
ROOF INSPECTION

WATER HEATER INSPECTION

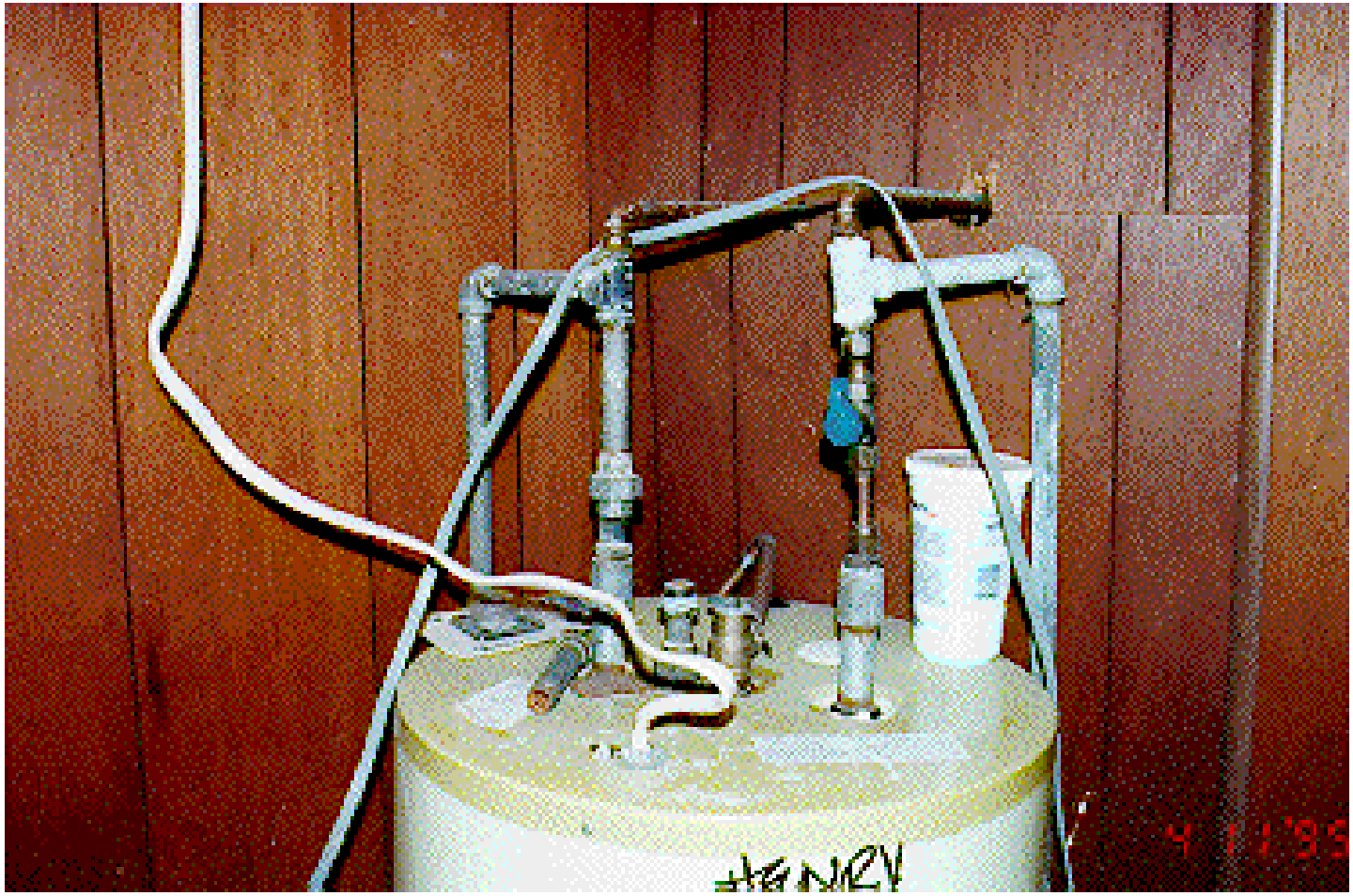

SUNMAX

ELECTRICAL INSPECTION




SHAW

PLUMBING INSPECTION



SYSTEM REQUIREMENTS

- Most simple, reliable systems
- History of installations and performance record
- Minimum maintenance
  - Low-income clients can not afford yearly maintenance
- Systems suited to climatic conditions
  - Freeze protection - major concern

SYSTEM REQUIREMENTS

- North Florida Systems
  - Indirect Active
  - Integral Collector Storage
  - Thermosiphon (Indirect)
- Central & South Florida Systems
  - Direct & Indirect Active
  - Integral Collector Storage
  - Thermosiphon

SIZING REQUIREMENTS

- Based on specific number of occupants
- Retrofit systems (low-cost)
  - used existing tank (40-52 gals)
  - replaced defective/old tanks
- Developed system sizing requirements
  - Per family size
  - Require set minimum performance
  - Florida Solar Energy Center certified systems

INSTALLATION REQUIREMENTS

- Collectors oriented due south (or within 45^0 either west or east of due south)
- Collectors mounted at an angle +-15° from latitude
- Anti-scald valve for pumped systems
- Insulation values for tank/piping
- Identical to FSEC approved system form
- System were inspected

INSTALLATION REQUIREMENTS

- Conventional water heater
  - Pumped Systems
    - » Set upper element to 125°F - 130°F
    - » Set lower element to low setting
  - ICS systems
    - » No adjustments required or set to 125
- Anti-scald valve installed
  - Set to provide water at 125°-140°F

SOLAR VENDOR APPLICATION

- Request for Contractor Qualification
- Serves to qualify contractor and system
- Basic information on company
  - Experience
- List of systems for various household sizes
- Warranties
- Occupational requirements
  - Insurance, etc.
- Local permit requirements for solar installation

Procurement Process

- List of approved contractors and systems
- Local WAP agencies identified residences
- Local WAP agencies bid out work to contractors
  - some did not bid and used local contractors with qualified systems (FSEC advised)
- Cost of installation already pre-arranged
- Local agencies eventually used contractor that did best work

POST INSTALLATION

- Systems were inspected
  - FSEC developed system inspection form
  - Homeowner's manual
  - Freeze protection information label
  - Warranty document
- Local agencies should inspect systems
- FSEC conducted spot inspections (25%)

TRAINING

- Program participants
  - Administrative
  - Technical
- Program descriptions and guidelines
- Solar technology
  - solar principles
  - solar systems

TRAINING

- Site solar and materials inspection training
  - on-site, field
  - standardized inspection forms
- System installation inspection training
  - on-site, field
  - standardized inspection forms

ISSUES TO ADDRESS

- Local permit requirements
- Warranty
  - Low cost often means short warranty
- Long term maintenance
- System selection (several types)
- System/installation bidding and procurement
- Commitment to program on part of all participants

SWAP EVALUATION

- Inspections
- Surveys
- “Hard” (instrumented) monitoring
- “Soft” (utility bill) monitoring

SWAP EVALUATION GOALS

- Determine the energy savings of low-cost SDHW systems in low-income homes in Florida
- Calculate savings-to-investment ratio (SIR) from NEAT procedure
- Evaluate the feasibility of SDHW as a WAP program measure
- Determine hot water use profiles of low-income families

SWAP EVALUATION GOALS

- Assess perceptions of homeowners receiving solar systems
- Determine percentage of electric bill devoted to water heating

SWAP INSPECTIONS

- **Collector**
- **Valves**
- **Wiring**
- **Exterior and Interior Piping**
- **Pump**
- **Controls**
- **Storage Tanks**
- **Component/System Operation**
- **Temperature Measurements**
- **Component Deterioration**
- **Vandalism**

SWAP INSPECTION SUMMARY

- Few component failures
- Most installation problems are easily fixed
  - most related to craftsmanship
- Inspections are critical
  - FSEC developed inspection forms
  - Agencies have to be committed

SWAP Surveys

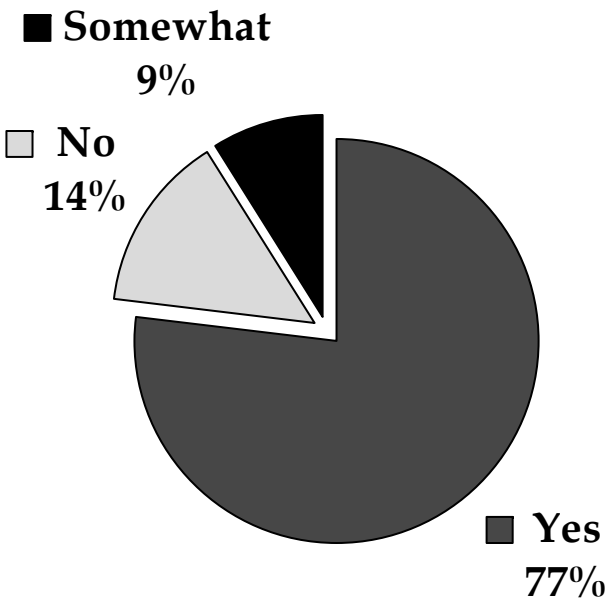
- Surveys sent to all system owners
- 35% response rate
- Provided clients with a future contact

SWAP SURVEYS

- **Satisfaction with solar system**
- **Hot water usage patterns**
- **Effects of system on lifestyle**
- **Seasonal and daily hot water supply changes**
- **Water consumption profiles**
- **Inconveniences of solar system**
- **System problems/failures**
- **Perceived reduction in utility bills**
- **Changes in occupancy (+/-)**
- **Vacation periods (no hot water usage)**

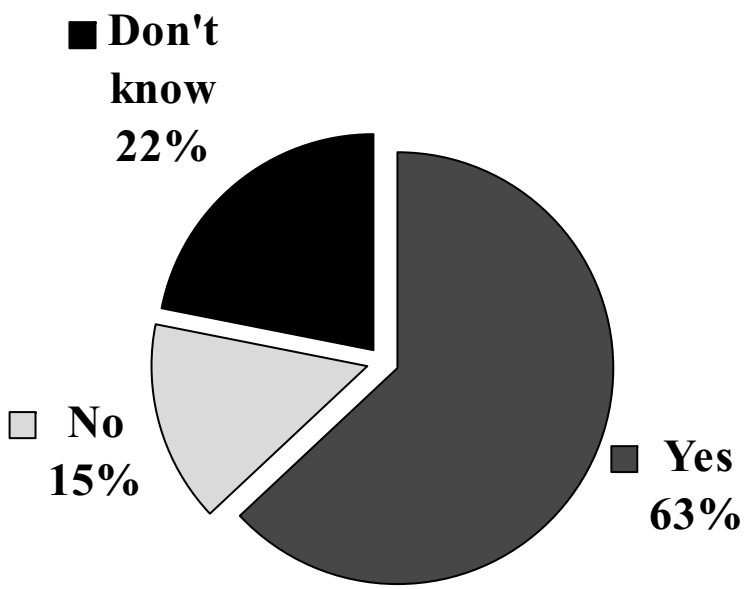
SWAP SURVEY RESULTS

Are you satisfied with your solar system?



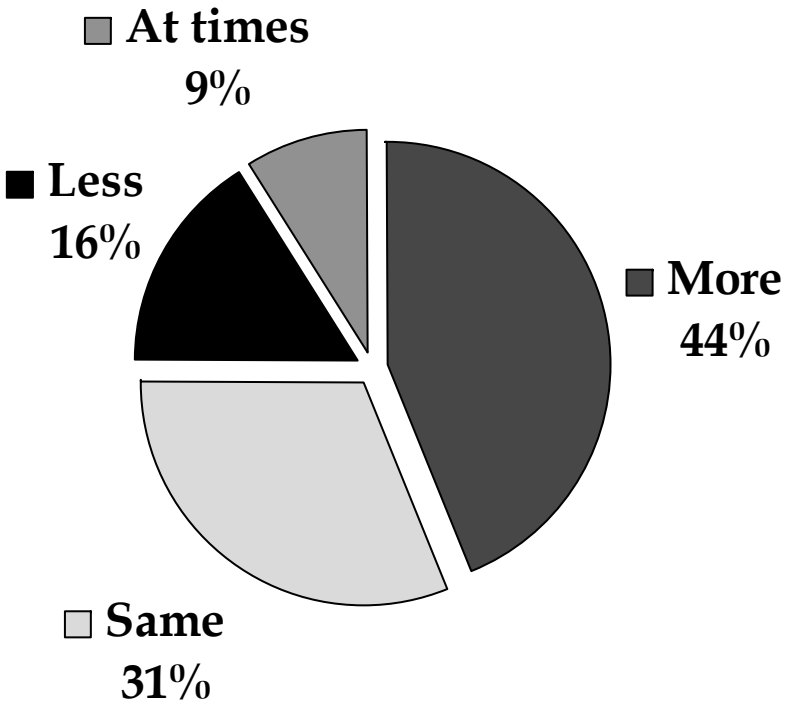
SWAP SURVEY RESULTS

Do you see any reduction in your utility bill?



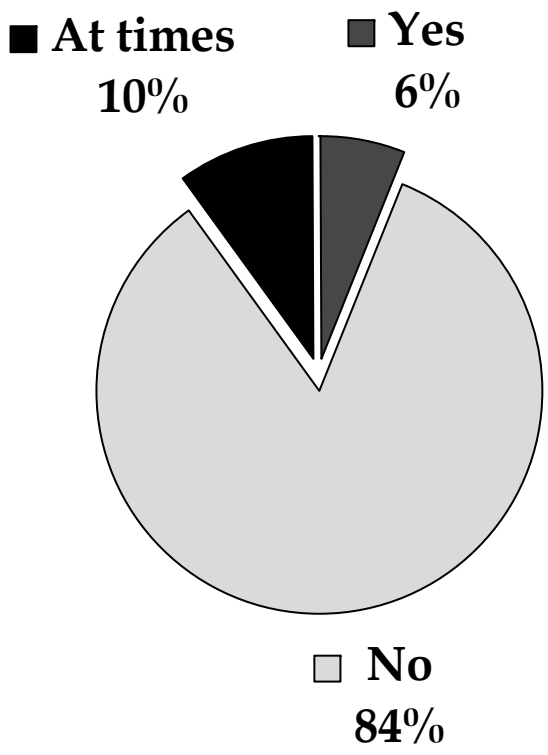
SWAP SURVEY RESULTS

Do you have more hot water than you had before the solar was installed?



SWAP SURVEY RESULTS

Does the solar system inconvenience you in any way?



SWAP SURVEY SUMMARY

- Most participants satisfied
- Participants sensitive to weather sensitive nature of solar system operation
- Participants would like more information about solar system
- Education program needed

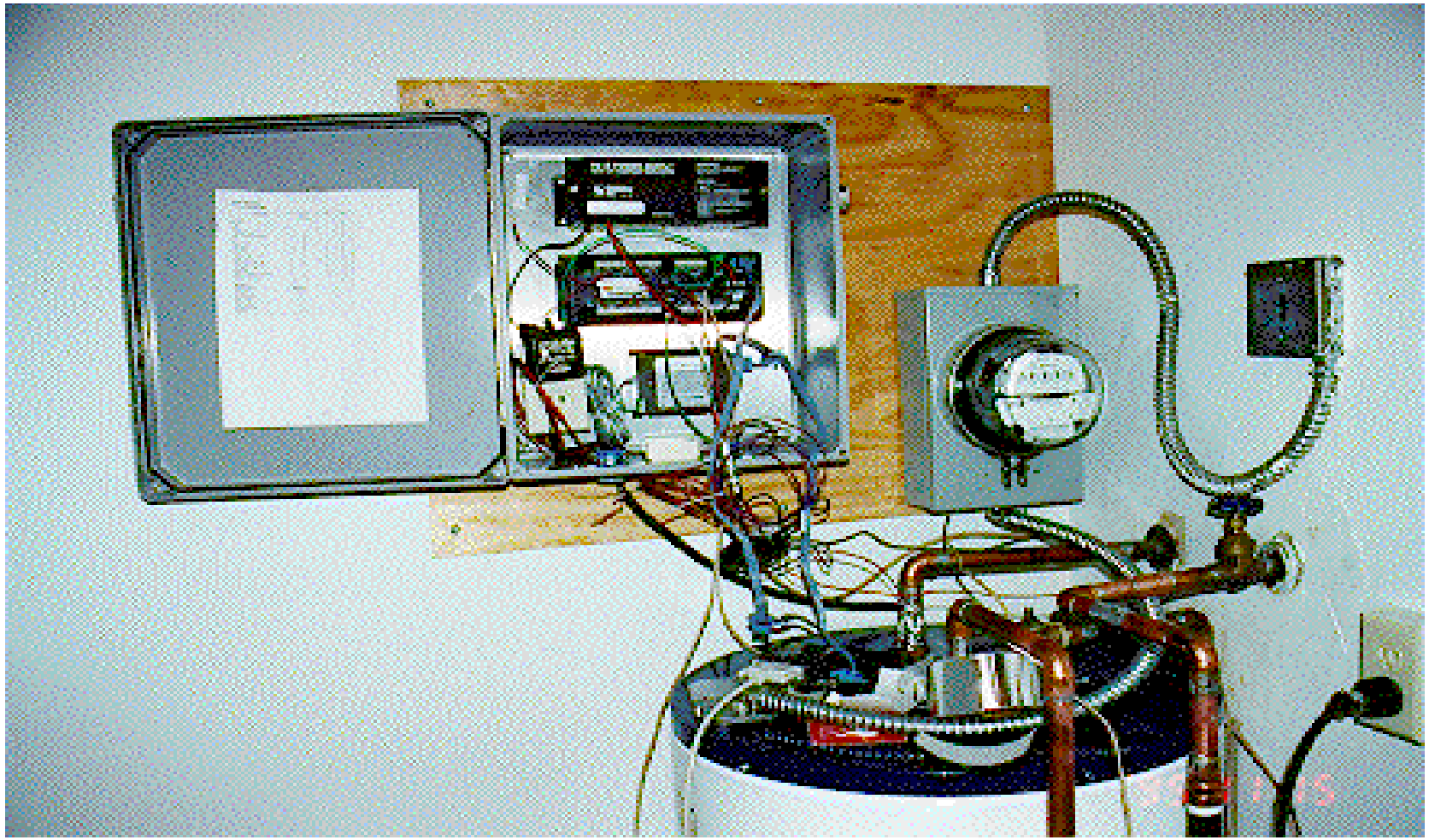
Instrumented Monitoring

- Monitored 32 systems total (35)
- North - 6
- Central - 13
- South - 13
- Various types of systems
- Monitored 1 year before solar installed
- Monitored 1 year after system installed

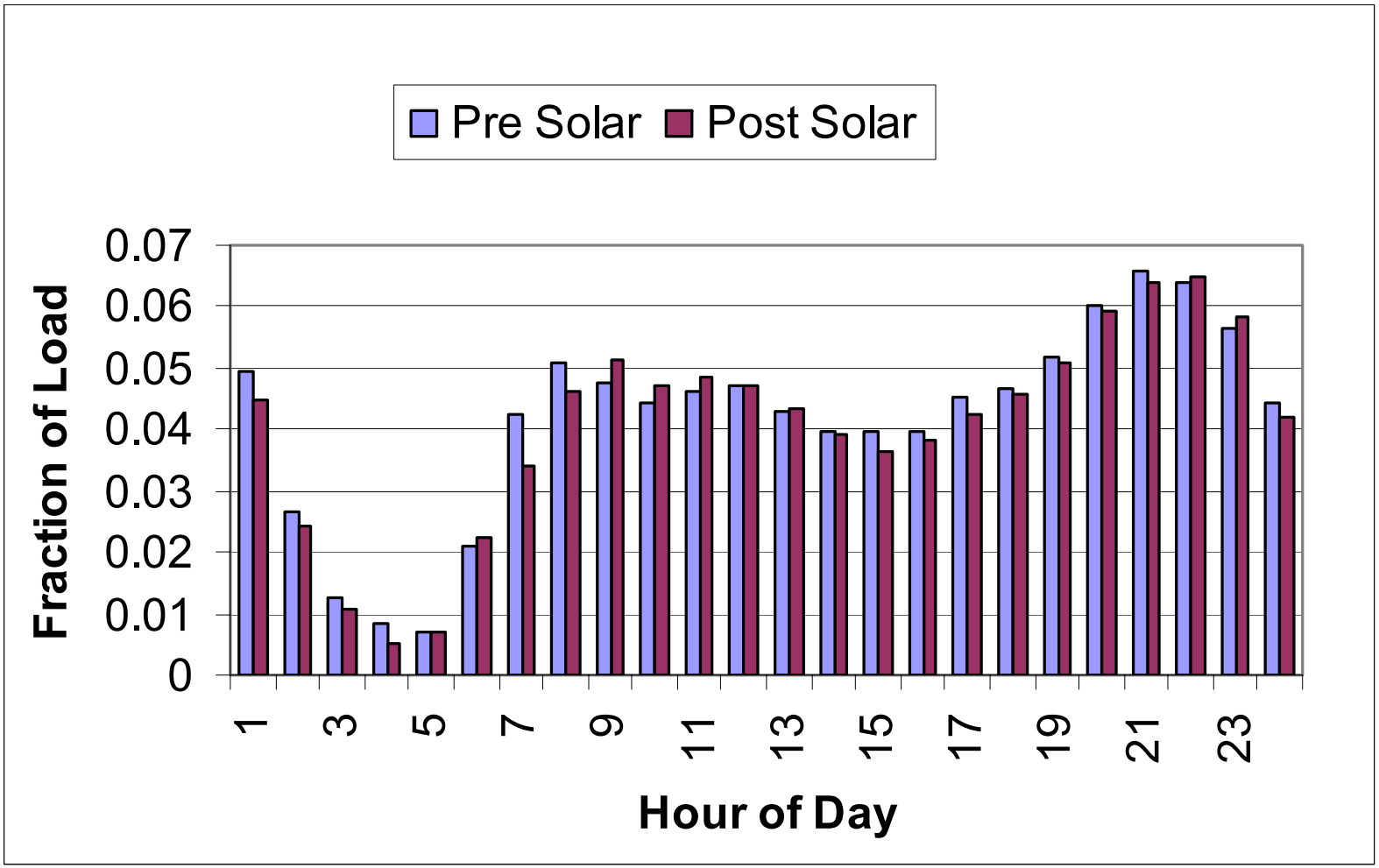
SWAP HARD MONITORING INSTRUMENTATION

- **Monitored cold water, hot water, collector feed and return temperatures.**
- **Monitored flow to tank and energy usage of tank.**
- **Monitored horizontal solar radiation.**
- **One time measurement of pump and controller power usage.**
- **Scanned data every 15 Sec. Stored averages/totals every 15 Min.**

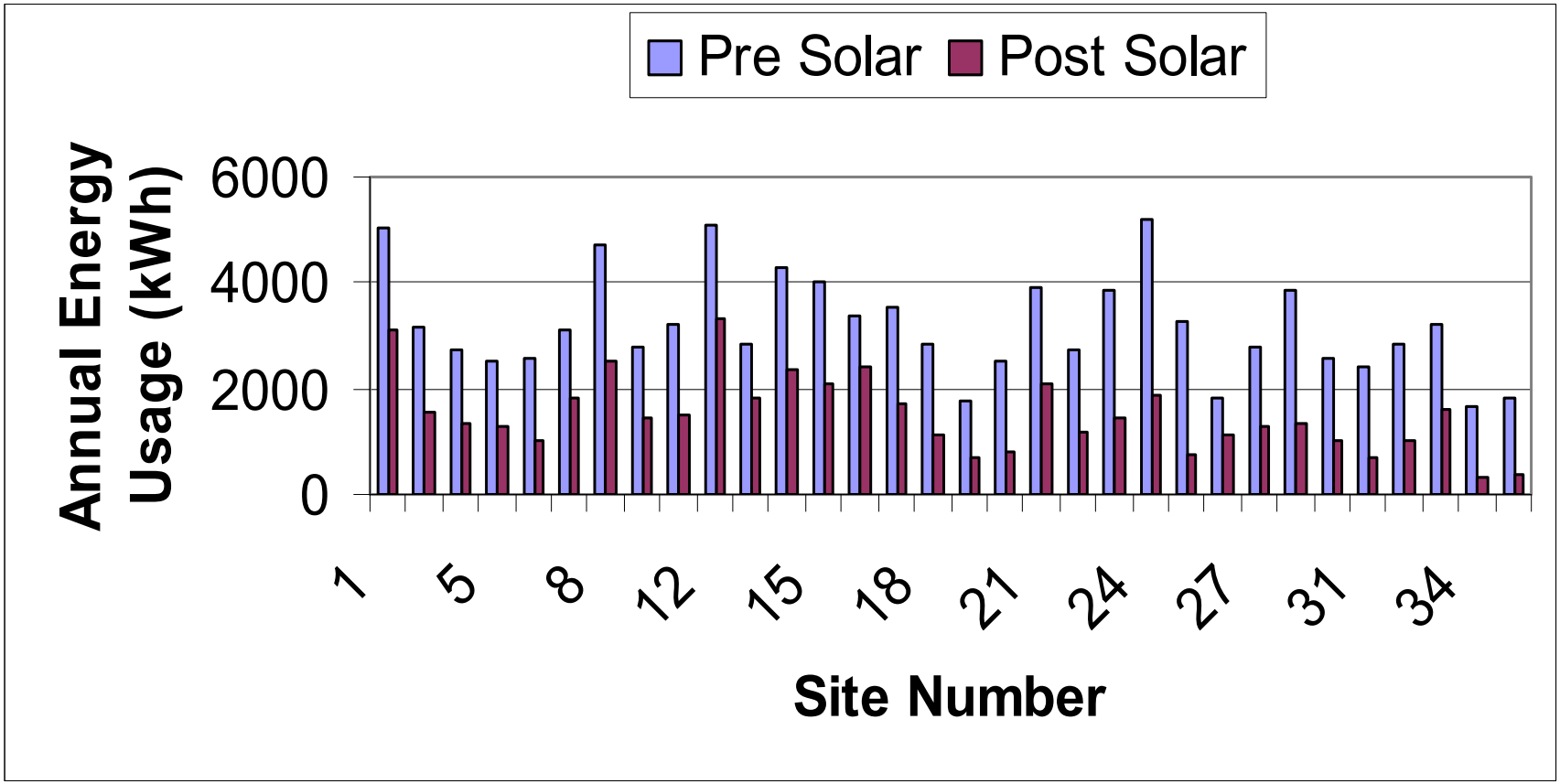
SWAP MONITORING EQUIPMENT



WATER USAGE PROFILE

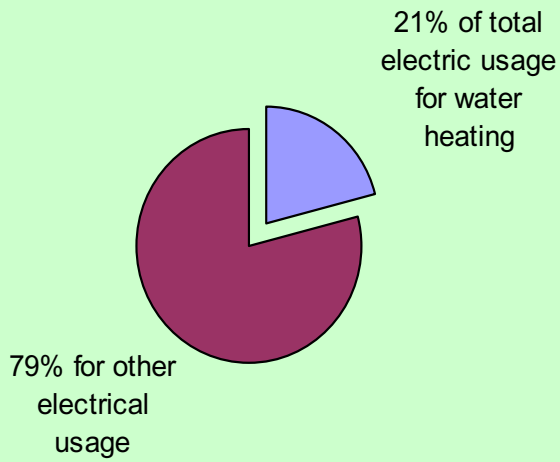


ANNUAL ENERGY USAGE

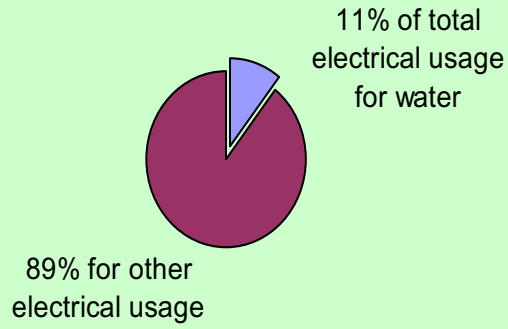


WATER HEATING RATIO

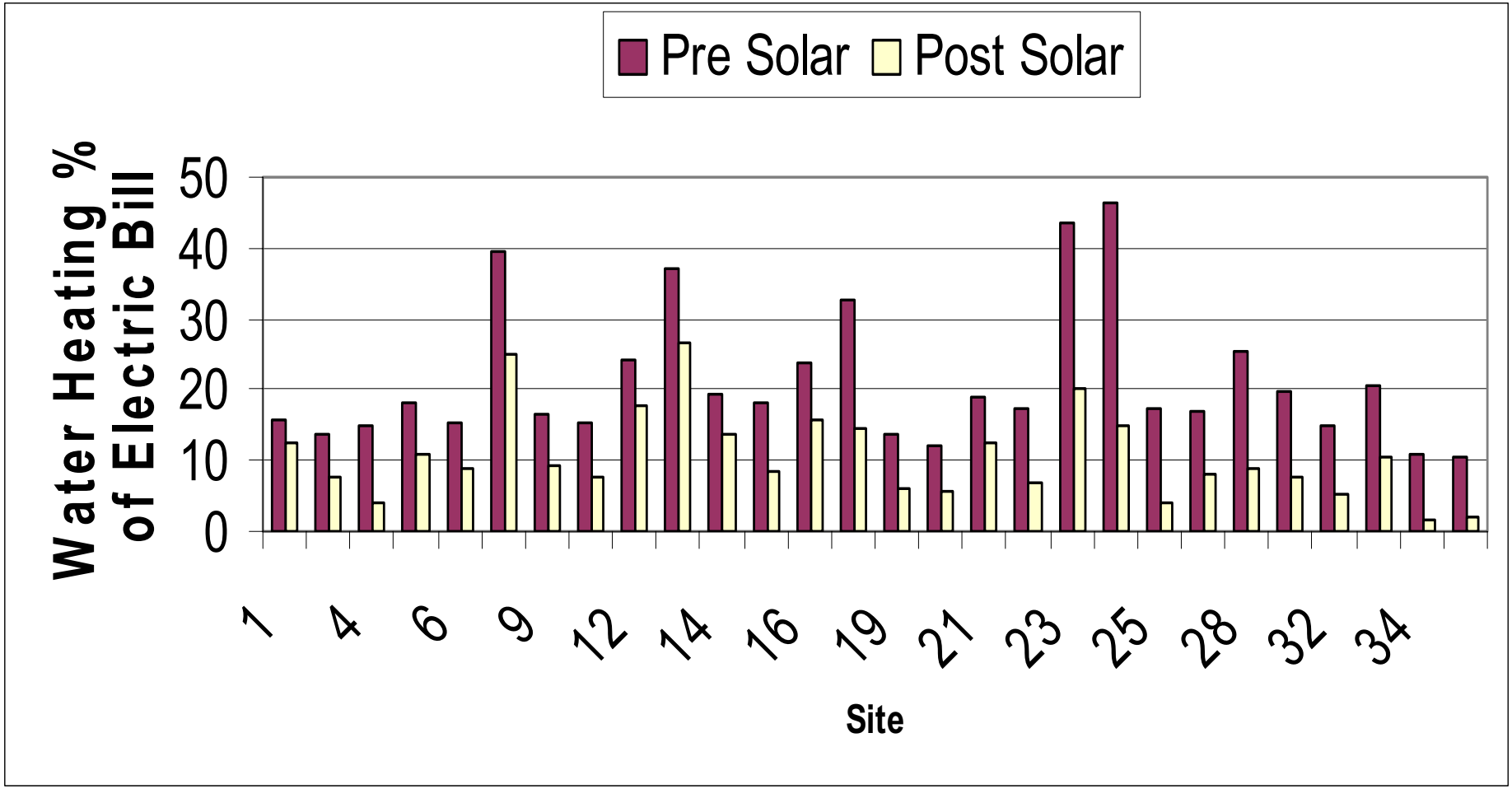
Percentage of total residence electricity used to heat water (Pre Solar)



Percentage of total residence electricity used to heat water (Post Solar)



WATER HEATING RATIO



SIR PARAMETERS

- Assume a discount rate of 4.7%.
- Assume a 20 Year life span.
- Assume $0.08 / kWh.
- Assume constant energy savings.
- Assume energy cost indices from NIST/DOE figures.
- Current National Energy Audit procedure does not include maintenance costs for evaluating weatherization procedures.

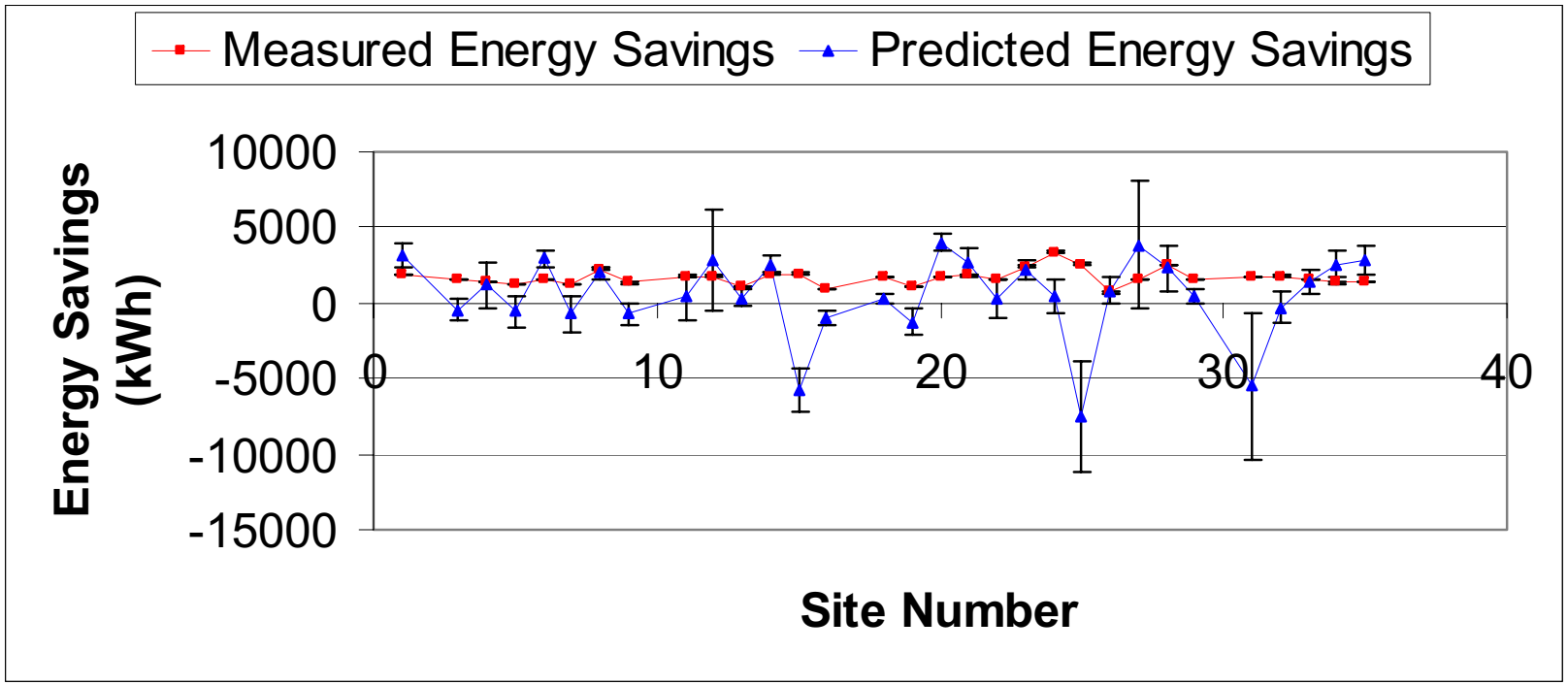
OVERALL RESULTS

Parameter	Pre Solar	Post Solar
Average family size	4.7	4.4
Average water heating energy consumption (kWh per system, per year)	3,100	1,500
Water heating costs per year ($.08 kWh)	$250	$120
NEAT Savings-to-Investment Ratio (at $.08 per kWh)	N/A	1.0
Solar Fraction (Percentage of hot water heated by solar)	N/A	0.53
Average system Coefficient of Performance	0.73	1.4
Average SWAP solar system installed cost	N/A	$1,550
Gallons used – Family per day	63.8	62.5
Gallons used – Per person per day	13.6	14.2
Average hot water temperature (^{0} F)	119	119

SWAP SOFT MONITORING

- Evaluate use of utility bill analysis as indicator of energy savings with solar
- Compare with hard monitoring savings
- Preliminary results indicate fair to poor fits with models for predicting annual energy usage
- Overall predicted savings are from 10-82% of measured savings for North, Central, South Florida

SWAP SOFT MONITORING PRELIMINARY RESULTS



The Ahmadi Family
Miami, FL

~Four occupants: 2 adults, 2 children

~25 ft^2 flat-plate collector

~52 gallon electric water heater

~Differential controlled active direct

~Uses on/off switch installed on water heater to cut electric off during sunny days.

Category	Pre Solar	Post Solar
Installed system	N/A	Active Pumped
Installed system cost	N/A	$1,550
Water heating energy usage (kWh per year)	2902	679
Water heating costs per year ($.08 kWh)	$232	$54
Water usage (Gals per day)	78	79
Solar Fraction	N/A	.77
NEAT Saving-to-Investment Ratio	N/A	1.4

The Sims Family Brooksville, Fla

~Four occupants: Single mother, 3 children ~30 gallon ICS unit

~Solar has become one of Mrs.. Sims favorite appliances.

~Helps reduce bills so she can continue going to radiologists school and hold down two jobs.

~"I also feel I'm doing my part in . . . helping save energy and the environment."

~"But, most of all I appreciate the savings and extra hot water."

Installed system	N/A	ICS
Installed system cost	N/A	$1,500
Water heating energy usage (kWh per year)	2367	846
Water heating costs per year ($.08 kWh)	$189	$68
Water usage (Gals per day)	59	44
Solar Fraction	N/A	.64
NEAT Saving-to-Investment Ratio	N/A	1.03

Local WAP Agency SWAP Manager

Brenda Mobley, SWAP Program Manager for the Mid Florida Community Action Agency, believes that ". . . A solar water system doesn't just help with the energy bill, it also relieves other financial stresses."

"For a program that reduces your energy bill and doesn't cost you a penny, the solar heater is the way to go. This program has proven itself to many low-income clients in Hernando and Sumter Counties. Several clients have made a point of telling me personally that the solar water heaters have cut their electric bill in half and have advised anyone to take advantage of this worthwhile program. The SWAP program has been very worthwhile in meeting Mid Florida's primary mission of reducing the energy and living costs of low-income clients."