IBACOS

HOME TO INNOVATION

Building America Research Update

2004 RESNET Conference

San Diego, CA

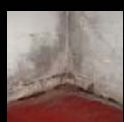
March 1, 2004

IBACOS' Current Projects

Whole House Analysis / Integrated Design Tools

Retrofit of Existing Buildings

•Implementation Strategies for High Performance Housing



Moisture Management

Foundation Systems

•Advanced Lighting Systems and Strategies

•Advanced HVAC Systems and Strategies

•Energy Efficient Hot Water Systems

Lighting Issues being studied

- Energy Baseline
- Advanced Lighting Design strategies
- Direct Replacement

DOE Baseline

- 0.8 w * Finished Floor Area + 455
- 90% incnadeescent, 10% fluorescent
- Hard wired and Plug-In lighting
- No consideration of light quality
  - Glare, contrast, shadows
- Annual Average Use Schedules
  - 6.49 Hrs Living spaces
  - 5.44 Hrs Bedrooms

Builder installed lighting varies significantly

- Low end, switched outlets, 1 surface mounted light per room
- Approx 1 fixture / 100 SF
- High end 10,000 SF house – lots of cans, accent, track, decorative
- 3 - 4 fixtures per 100 SF
- How do you compare equally?

IBACOS'S EXPERIENCES

- Simplified Modeling & Actual Design
- Take standard W/SF and make it "efficient"
- Direct Substitution just in Kitchen / Family room
- 901 kWh per year base case
- 309 kWh per year with substitution

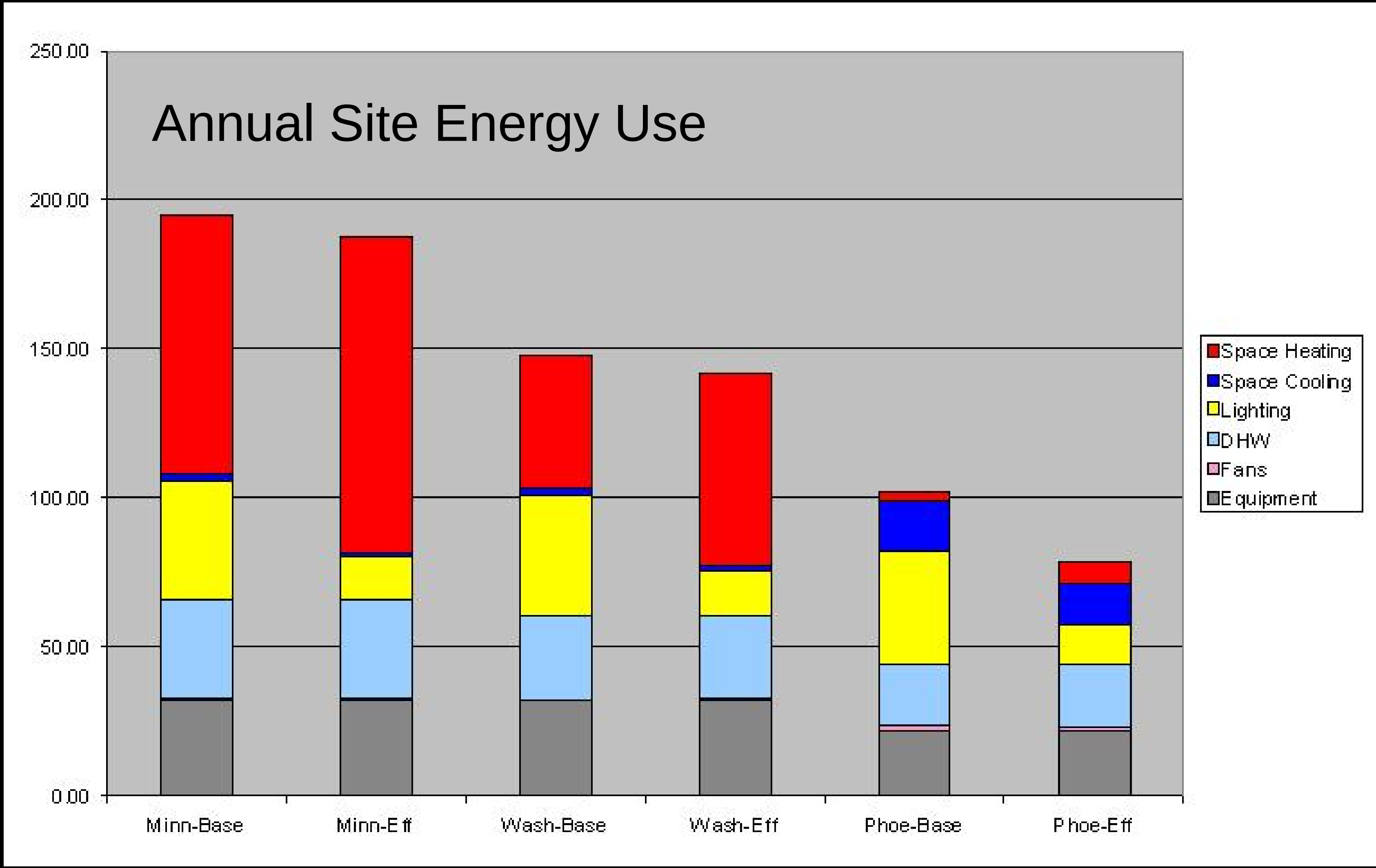
- 28% reduction in Total Annual Lighting Energy

Whole House Model

Annual Site Energy Use

	Minneapolis		Washington, D.C.		Phoenix	
	Base Case	Efficient	Base Case	Efficient	Base Case	Efficient
End-Use	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu
Space Heating	86.83	106.28	44.47	65.02	3.20	7.51
Space Cooling	1.68	1.13	2.30	1.52	16.51	13.44
DHW	32.80	32.80	28.10	28.10	20.40	20.40
Fans	1.30	1.47	0.87	1.05	2.20	1.85
Equipment	31.87	31.87	31.87	31.87	21.87	21.87
Lighting	40.33	14.48	40.33	14.48	38.06	13.73
Total	194.80	188.03	147.93	142.05	102.24	78.80
% savings		3.48		3.98		22.93

Whole House Model

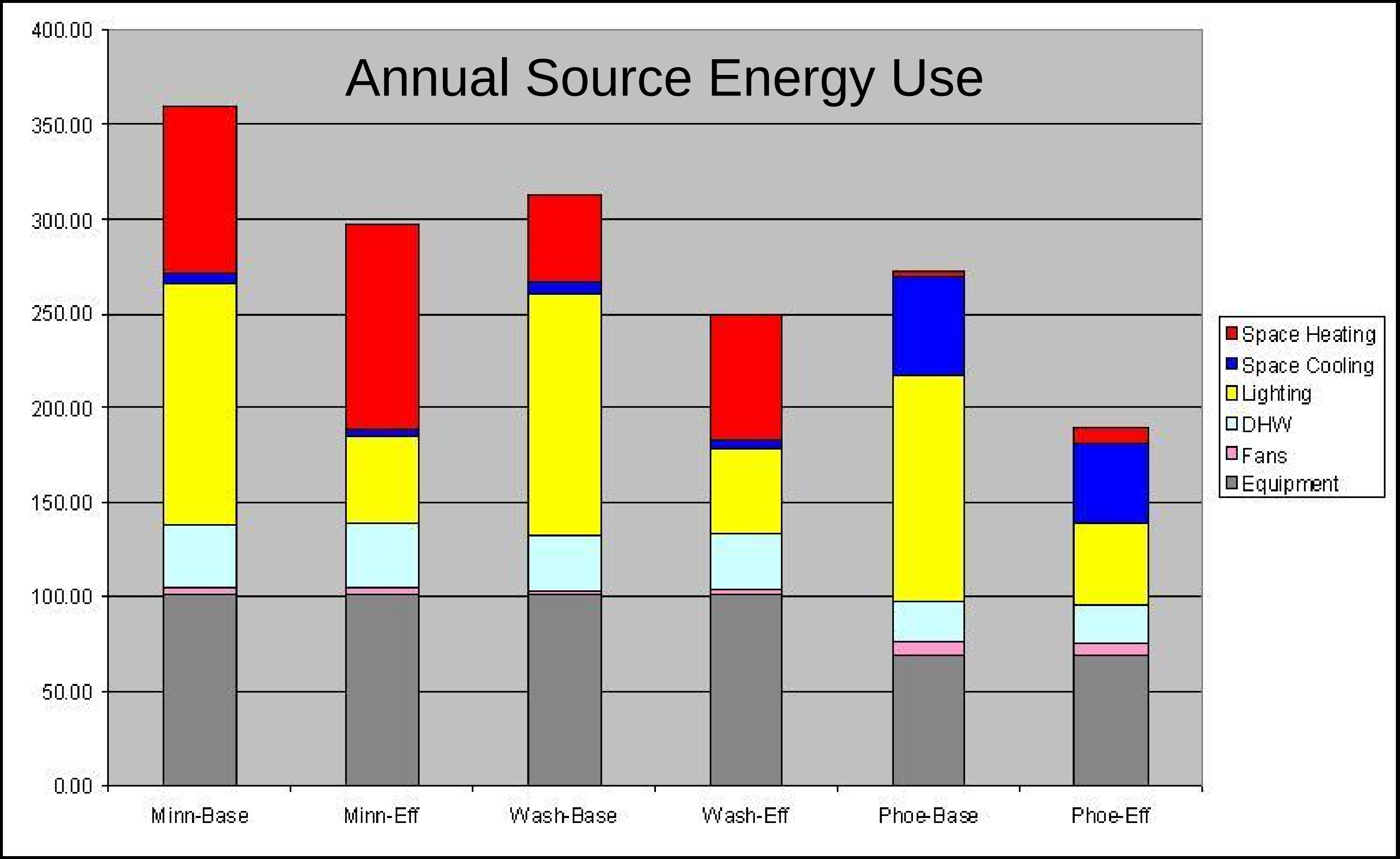


Whole House Model

Annual Source Energy Use

	Minneapolis		Washington, D.C.		Phoenix	
	Base Case	Efficient	Base Case	Efficient	Base Case	Efficient
End-Use	MBtu	MBtu	MBtu	MBtu	MBtu	MBtu
Space Heating	88.84	108.79	45.50	66.58	3.27	7.69
Space Cooling	5.30	3.56	7.27	4.81	52.16	42.46
DHW	33.46	33.46	28.66	28.66	20.81	20.81
Fans	4.11	4.65	2.74	3.33	6.95	5.85
Equipment	100.70	100.70	100.70	100.70	69.11	69.11
Lighting	127.45	45.77	127.45	45.77	120.28	43.38
Total	359.85	296.93	312.32	249.85	272.57	189.30
% savings		17.49		20.00		30.55

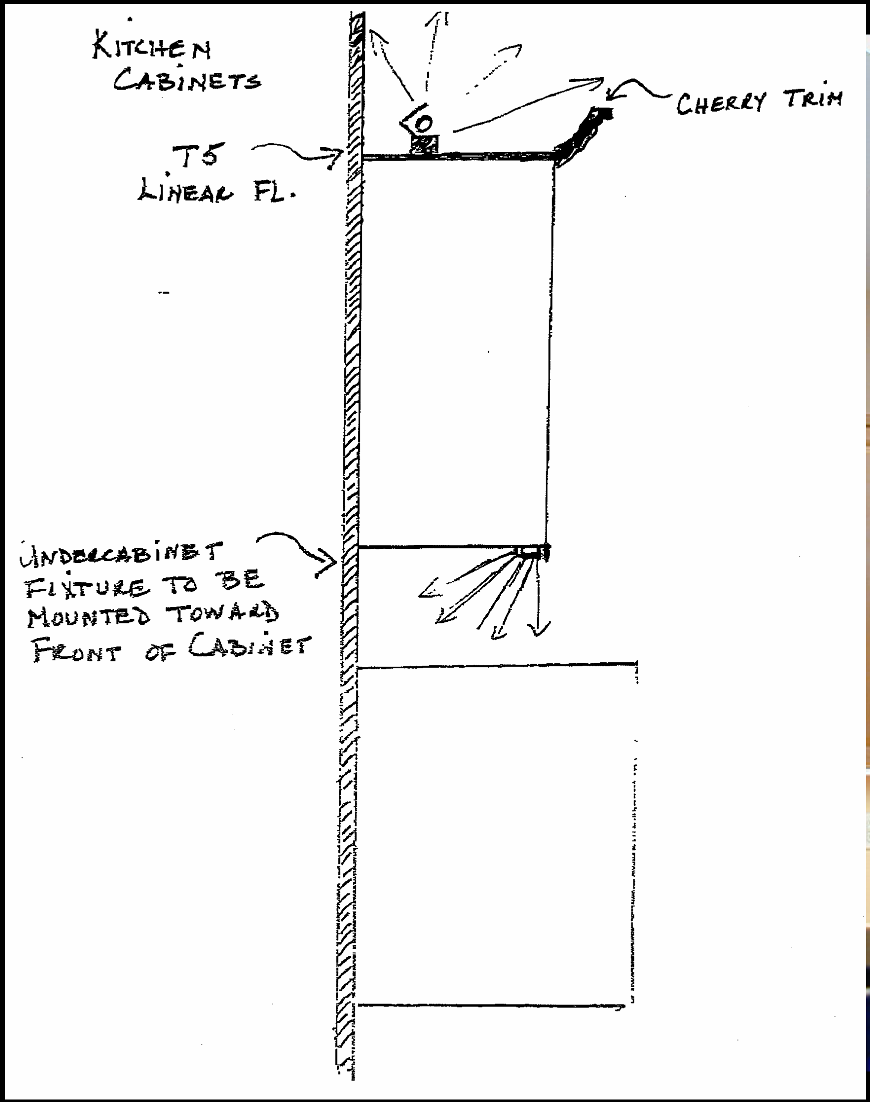
Whole House Model



Advanced Residential Lighting Design

- Look at lighting quality
- Concealed sources – Coves, valances, etc
- Layered lighting – Ambient, Task and Accent
- All fluorescent sources

Lighting



KITCHEN CABINETS
CHERRY TRIM
T5 LINEAR FL.
UNDERCABINET FIXTURE TO BE MOUNTED TOWARD FRONT OF CABINET

PEERLESS Faucet

Advanced Residential Lighting Design

- Larger Home
- 3121 Square Feet
- DOE Baseline – 2951 kWh Annual
- ARLD – All Fluorescent Sources
- 3867 kWh Annual - Hard Wired lighting only
- 31% increase

Advanced Residential Lighting Design

- Mid sized Home
- DOE Baseline – 1591 kWh Annual
- ARLD – All Fluorescent Sources
- 2208 kWh Annual - Hard Wired lighting only
- 38% increase

Potential Impact on Rating

- Simply counting % of lamps does not tell whole story
- Single "Average" Baseline may not be appropriate
- Unfortunately we don't have another answer yet

Efficient DHW Systems

- Size Matters
- But Technology Matters More

Efficient DHW Systems

- Water Heater Performance
- Factors Affecting Energy Efficiency
- Factors Affecting Sizing
- Testing Criteria
- Performance Results from TRNSYS Simulations

Efficient DHW Systems

- Factors that Impact Water Heater Energy Efficiency
- Fuel Conversion Efficiency
- Inlet (mains) Water Temperature
- Daily Hot Water Volume
- Standby Losses (Storage Volume)
  - Tank Set Point Temperature
  - Ambient Air Temperature
  - NAECA Minimum Efficiency Standards

Efficient DHW Systems

- NAECA Minimum Energy Factors (EF)
  - Domestic Water Heaters

	4-15-91	1-20-04
Gas-Fired Storage	0.62 – (0.0019V)	0.67 – (0.0019V)
Electric Storage	0.93 – (0.00132V)	0.97 – (0.00132V)

Minimum efficiency is tied to storage volume

EF decreases from smallest to largest sizes

- 13% decrease for electric
- 15% decrease for gas

Efficient DHW Systems

- Factors that Impact Water Heater Sizing
- Design Load Estimation Methods/Guidelines
- Hot Water Delivery Capacity
  - Inlet (mains) Water Temperature
  - Tank Set Point Temperature
  - On/Off Tolerance (differential temperature)

Efficient DHW Systems

• HUD-FHA Minimum Water Heater Standards

# of Bathrooms		1 - 1.5		2 – 2.5				3 – 3.5			
# of Bedrooms	1	2	3	2	3	4	5	3	4	5	6
Gas-Fired Storage	43	60	60	60	70	72	90	72	82	90	92
Electric Storage	30	44	58	58	72	72	88	72	88	88	102
Oil-Fired Storage	89	89	89	89	89	89	89	89	89	89	89

• Adopted by ASHRAE and ASPE

• No longer used by HUD-FHA

Efficient DHW Systems

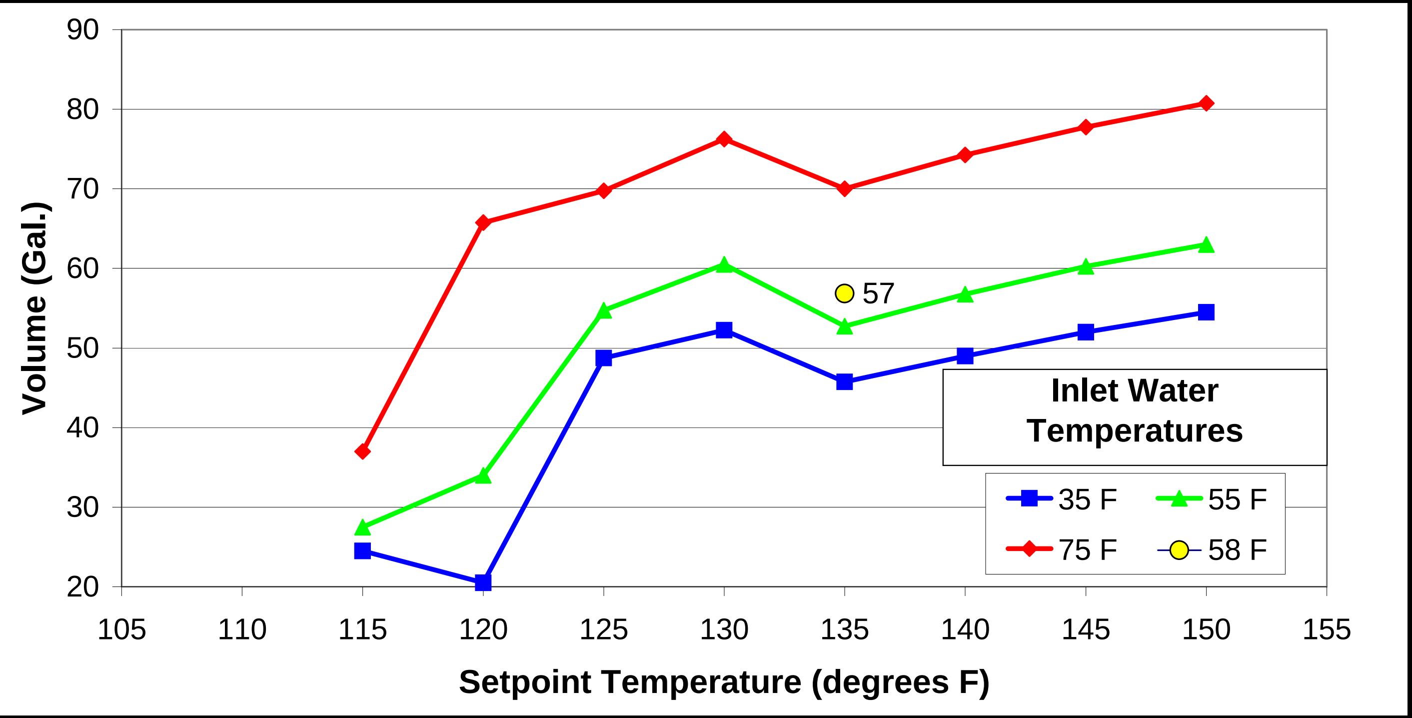
- Water Heater Rating Criteria

	DOE Test Procedure	Conventional Controls	Energy Smart Controls
Draw Initiation:	Upper Element OFF	Upper Element OFF or Set Point Temperature Achieved	
Draw Termination:	T_{MAX} - 25°F	105°F	105°F
Initial Tank Temp.:	135°F ± 5°F	T_{SP} - 10°F	T_{SP} - 5°F
Set Point Temp.:	135°F ± 5°F	115°F - 155°F	110°F - 155°F
Upper Element Diff.:	unspecified	20°F	5°F
Lower Element Diff.:	unspecified	10°F	5°F
Supply Water Temp.:	58°F ± 2°F	55°F	55°F
Ambient Air Temp.:	65°F to 70°F	67.5°F	67.5°F
Water Draw Rate:	3.0 ± 0.25 gpm	3.0 gpm	3.0 gpm

Efficient DHW Systems

Water Heater Performance

First Hour Rating



- 50-Gallon Electric Water Heater
  - Conventional Controls

Efficient DHW Systems

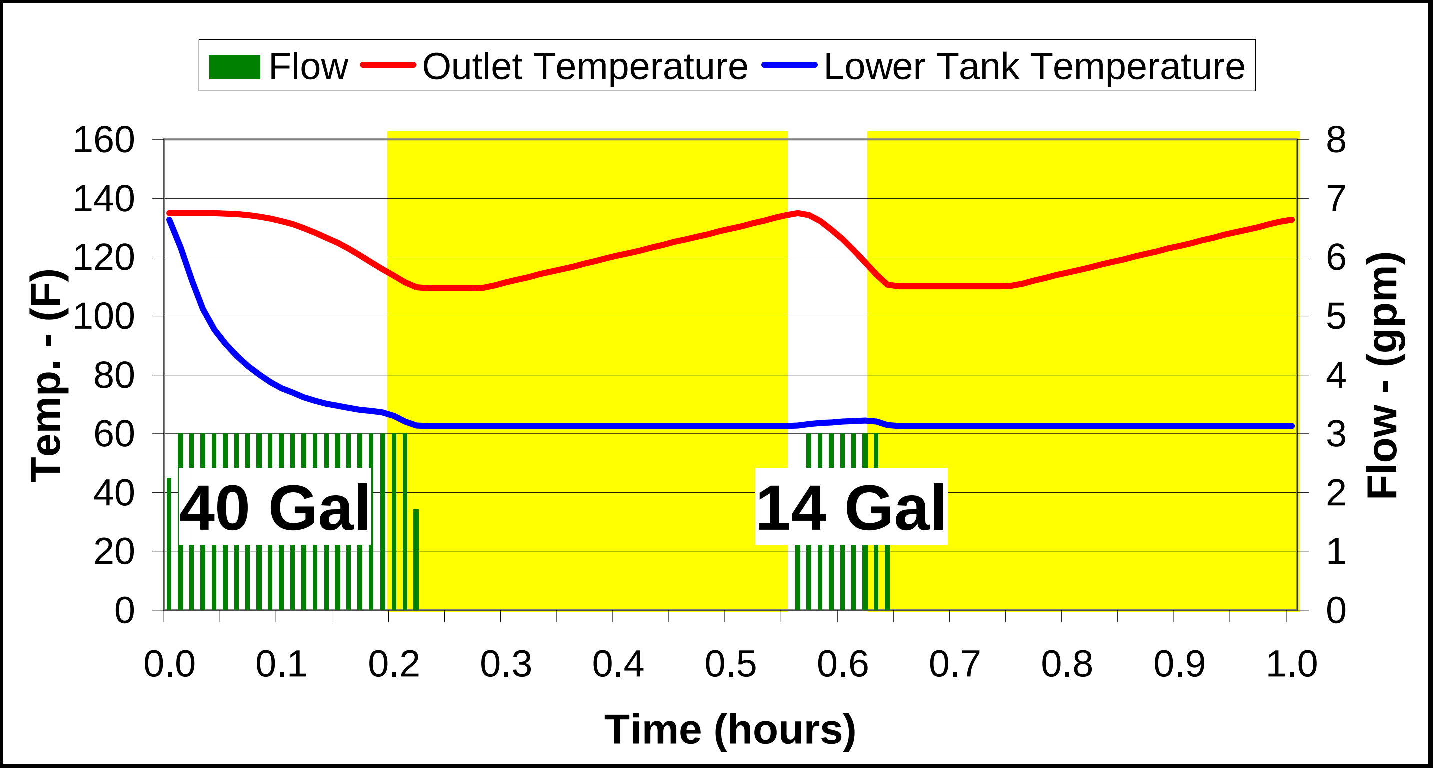
Water Heater Performance

T_{SP} =135°F

T_I = 58°F

T_T =135°F

T_{MIN}=110°F



- 50-Gallon Electric Water Heater
  - Conventional Controls

Efficient DHW Systems

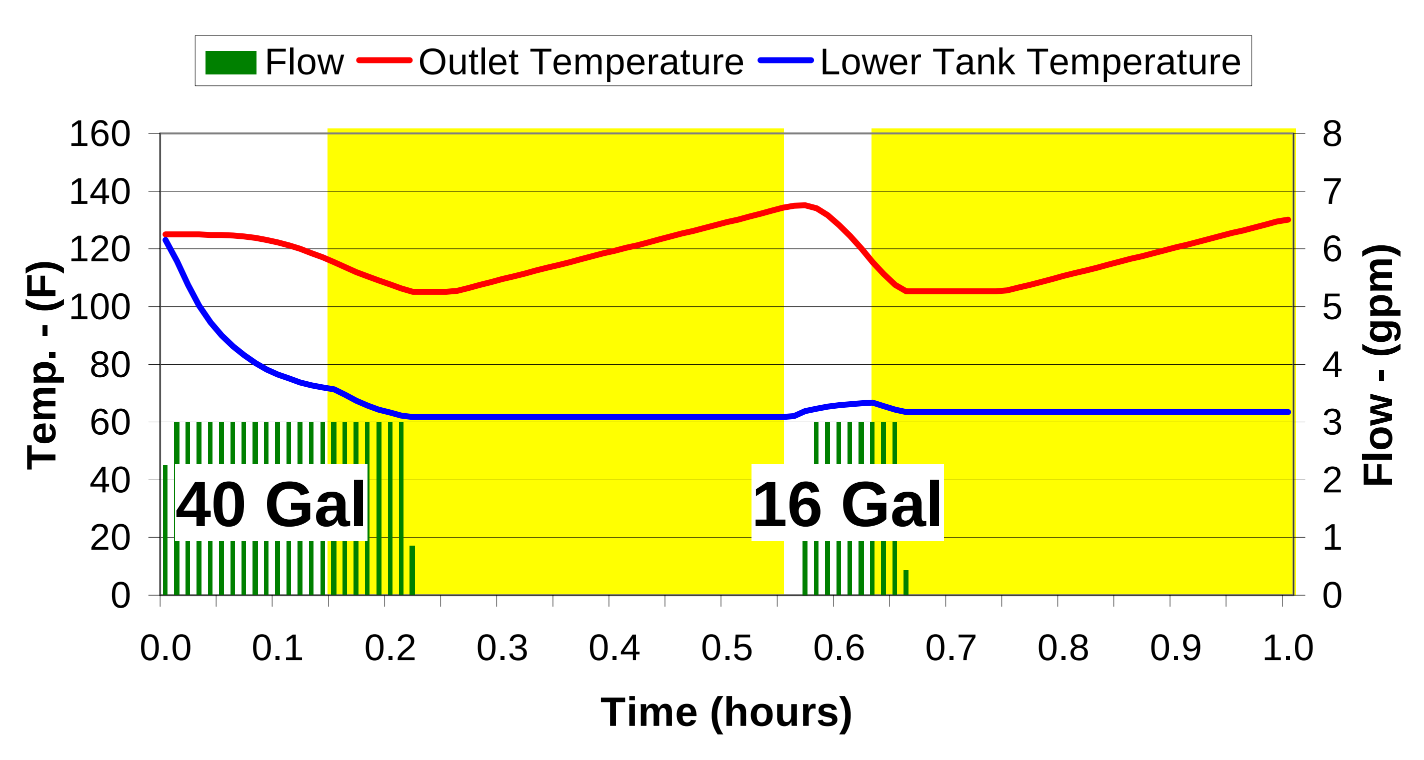
Water Heater Performance

T_{SP} =135°F

T_I = 58°F

T_T =125°F

T_{MIN}=105°F



- 50-Gallon Electric Water Heater
- Conventional Controls

Efficient DHW Systems

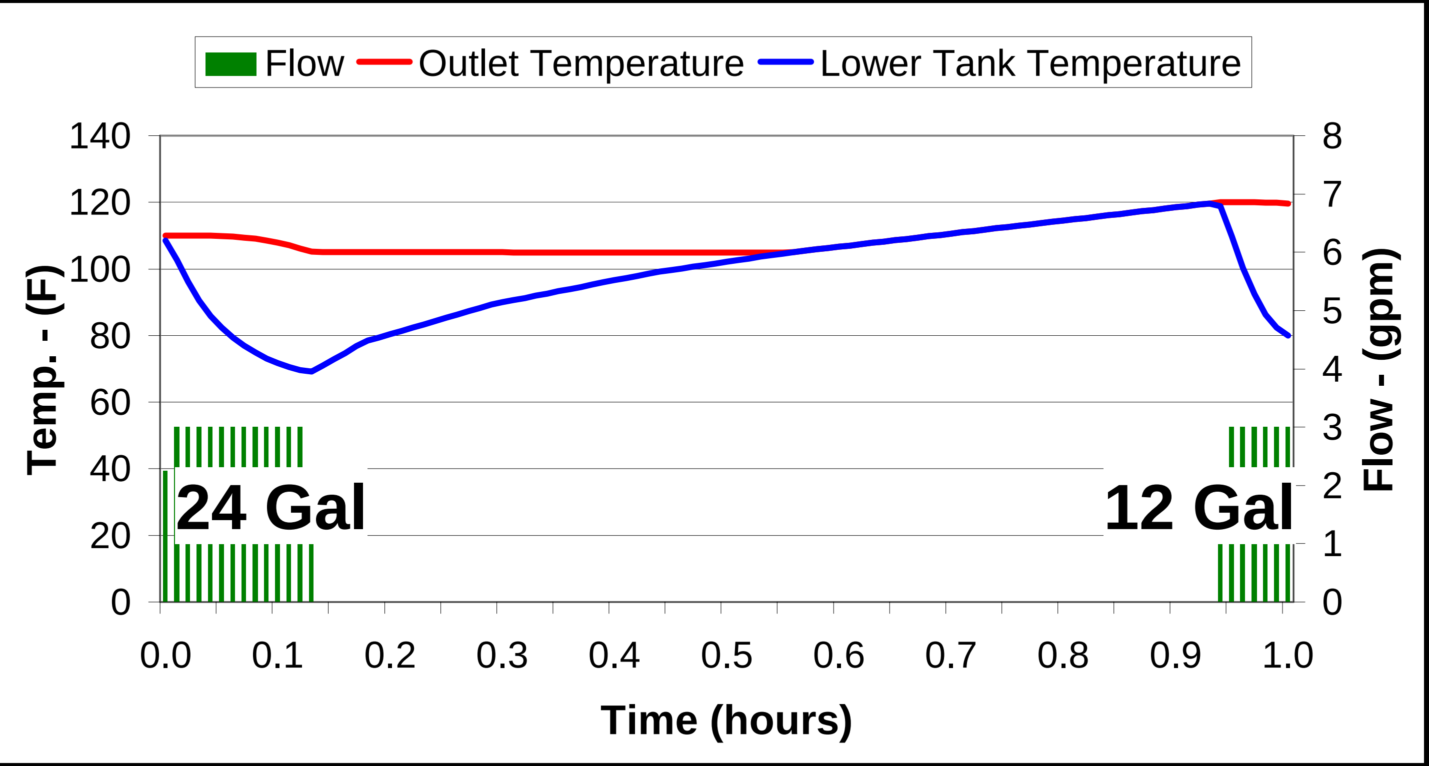
Water Heater Performance

T_{SP} =120°F

T_I = 55°F

T_T =110°F

T_{MIN}=105°F



- 50-Gallon Electric Water Heater
- Conventional Controls

Efficient DHW Systems

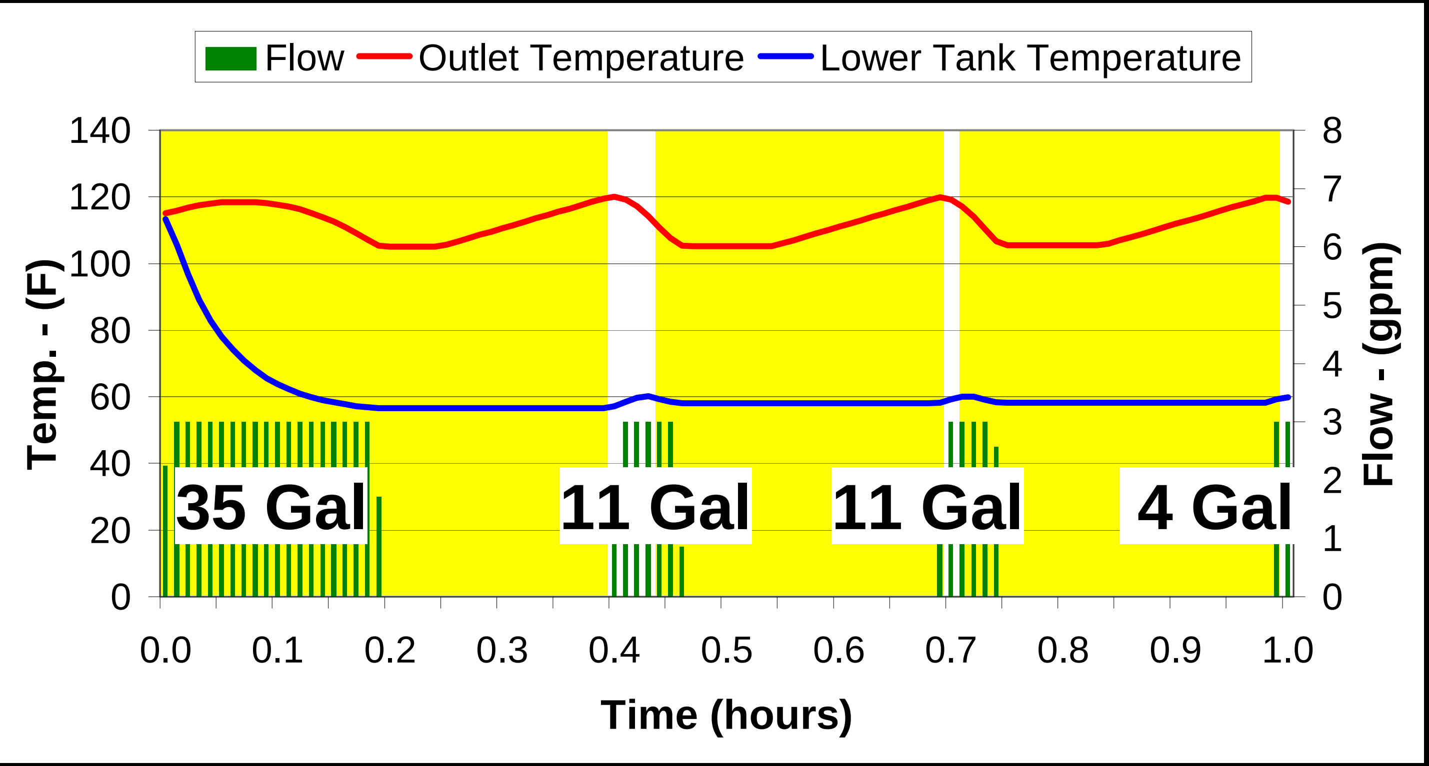
Water Heater Performance

T_{SP} =120°F

T_{I} = 55°F

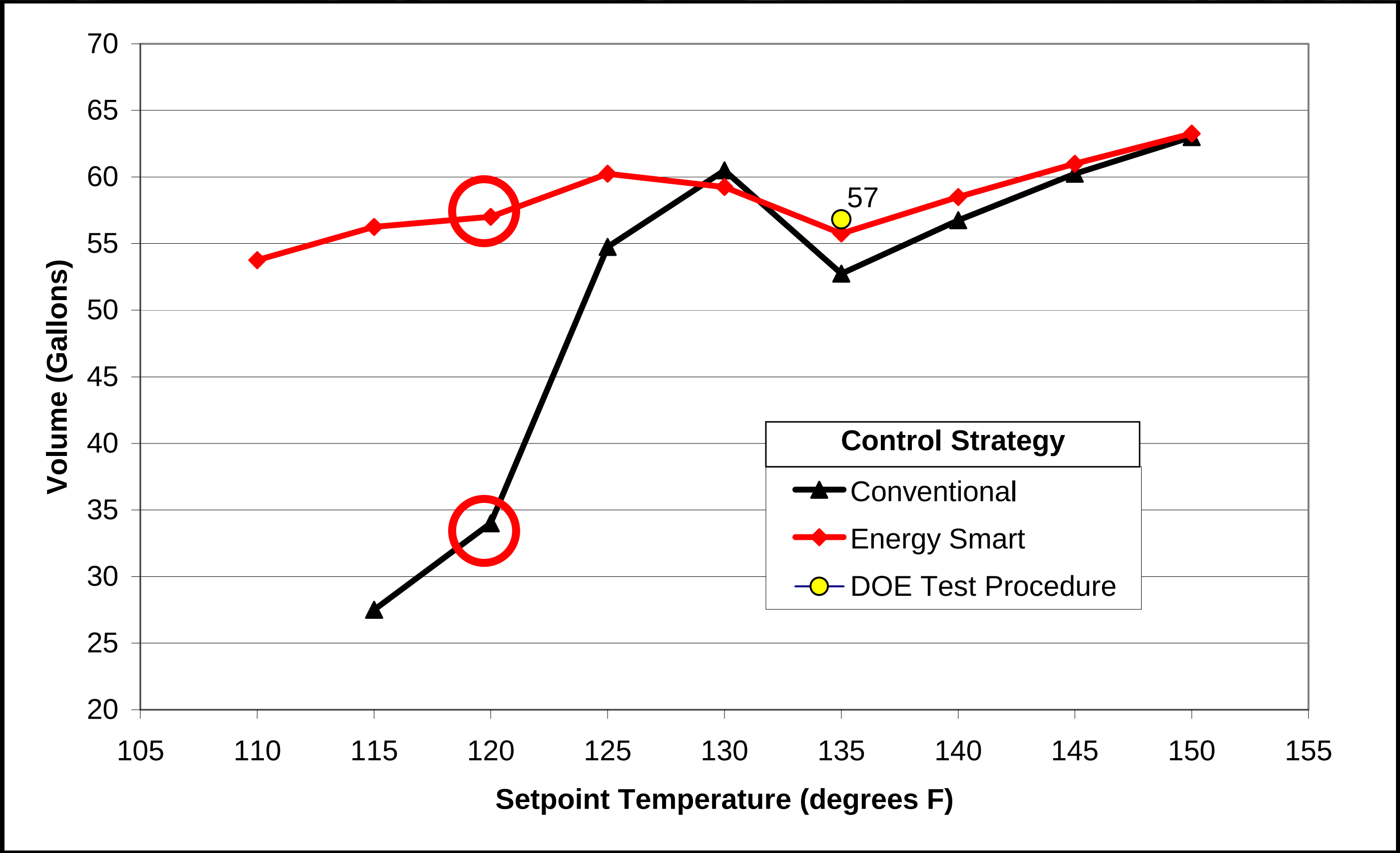
T_{T} =115°F

T_{MIN}=105°F



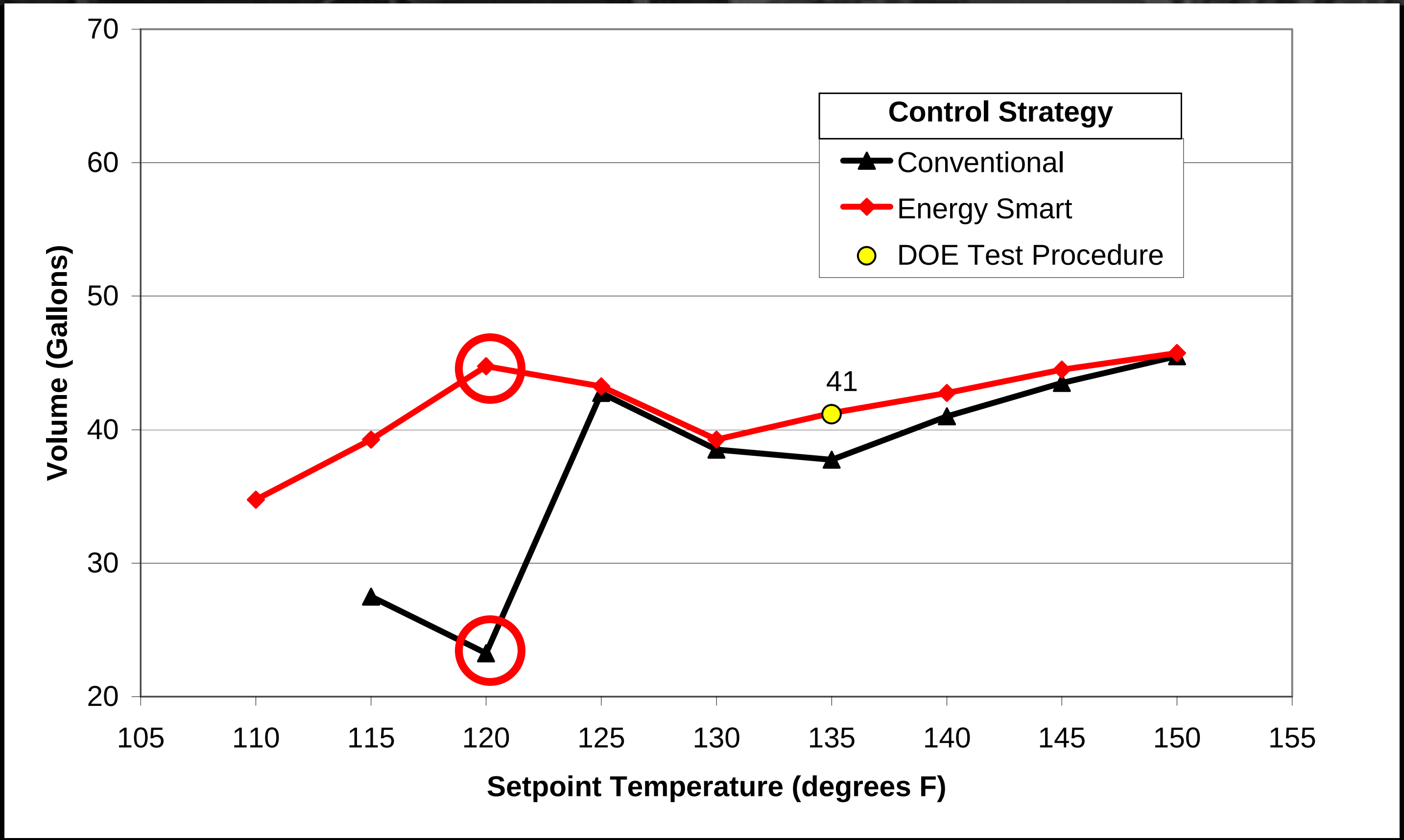
- 50-Gallon Electric Water Heater
- Energy Smart™ Controls

Efficient DHW Systems



- First-Hour Rating – 50-gallon electric water heater

Efficient DHW Systems



- 30-Minute Rating – 50-gallon electric water heater

The Hot Water Boundary

- Best Performing current Technology
  - Sealed Combustion High Output
  - Instantaneous Gas
  - Heat Pump Water Heater

- Issues are cost and capacity

The Hot Water Boundary

- A major limit to adequate performance is incoming water temperature
- Heat Pump would have more rapid recovery and Instant Gas could be significantly smaller if we had a higher inlet temperature

So, what about heat recovery

Increased inlet temperature from pre-tempering

The Hot Water Boundary

- GFX, ineffective due to coincident operation. It is best during showers.
- We are exploring non-coincident water heat recovery.
- Direct exchange, heat pump, small solar (Northern solution)
- Water stored at 80 to 90 degrees has almost no loss to the home, and reduces needed rise by 40 %

The Hot Water Boundary

- Key Next Steps
- TRYNSYS model for water heaters and storage
- Definition of base case for system efficiency
  - Is it % energy compared to standard ground water temperature source?
  - How much use in what pattern?
  - What distribution efficiency for the system?

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Duncan Prahl
dprahl@ibacos.com