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# Combi Systems: Lessons Learned from the Field

## 2015 ACEEE Hot Water Forum

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Center for Energy and Environment

# Sponsors and Partners

- NorthernSTAR - A DOE Building America Research Team
- Sustainable Energy Resources for Consumers Grants

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Sustainable Resources Center
Creating Healthy & Efficient Homes

UNIVERSITY OF MINNESOTA
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The ENERGY CONSERVATORY
DIAGNOSTIC TOOLS TO MEASURE BUILDING PERFORMANCE

# Introduction to Combi Systems

- Integrated space heating and domestic hot water
- Two main types:
  - Hydronic space heating
  - Forced-air space heating
- New equipment has several advantages
  - High efficiency
  - Wide range of loads
  - Sealed combustion

## COMBINED WATER AND SPACE HEATER
USING STORAGE WATER HEATER

# Our project

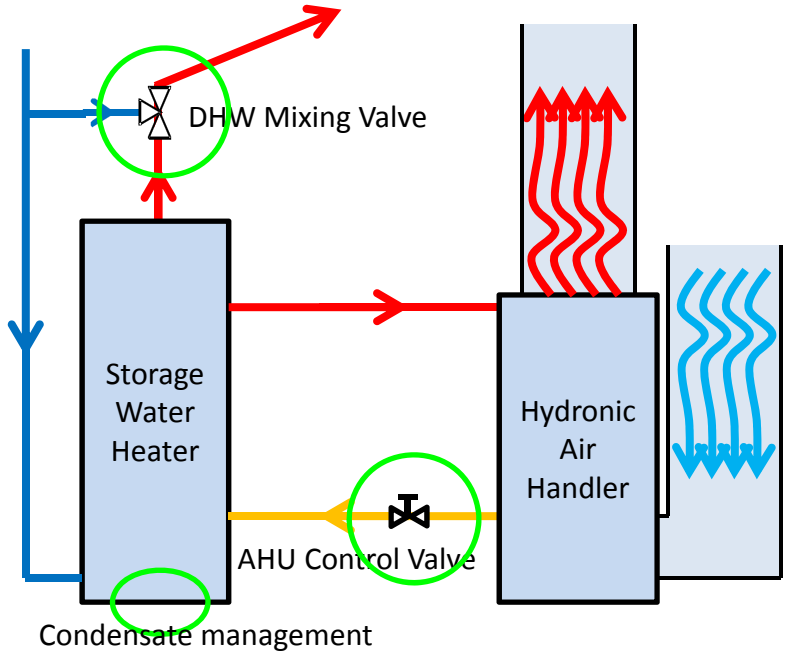
- Low income weatherization
  - Orphaned water heaters
- Focus on Natural Gas Forced Air Systems
- Laboratory Testing
  - Support of Implementation
- **Field Implementation – 200+ homes**
  - Low income weatherization in Minnesota
- **Detailed Field Study – 20 homes**
  - Representative sample of implementation

# Lessons Learned

- Installation
- Optimization
- Operation
- Programs/Rebates
- Cost
- Future

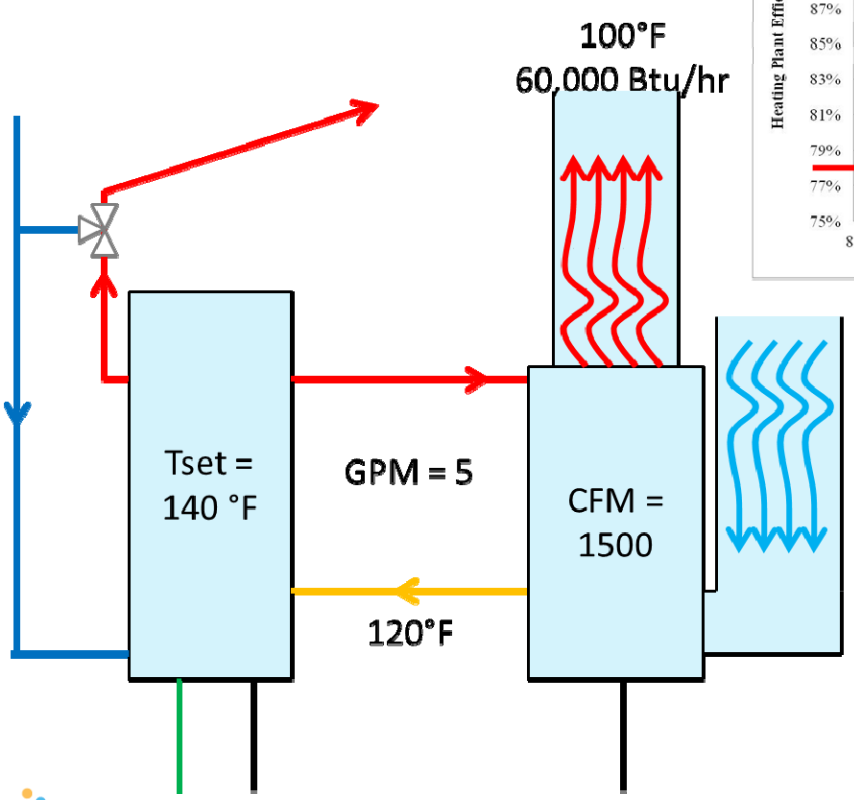
# Installation

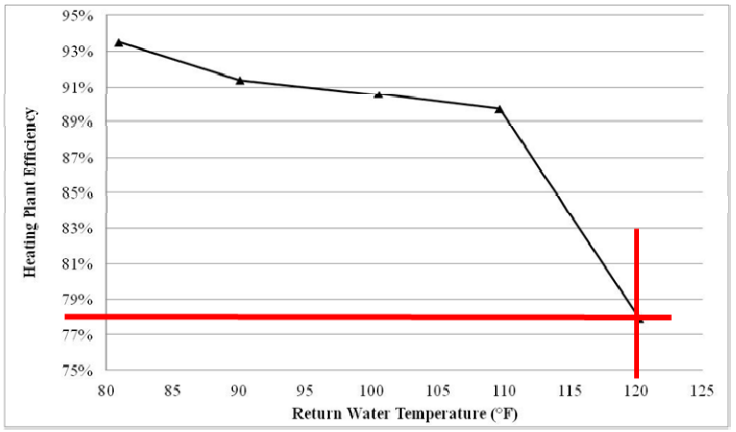
- Venting
- Mixing valve
- Condensate pump
- Air handler flow rate control valve
- Sizing



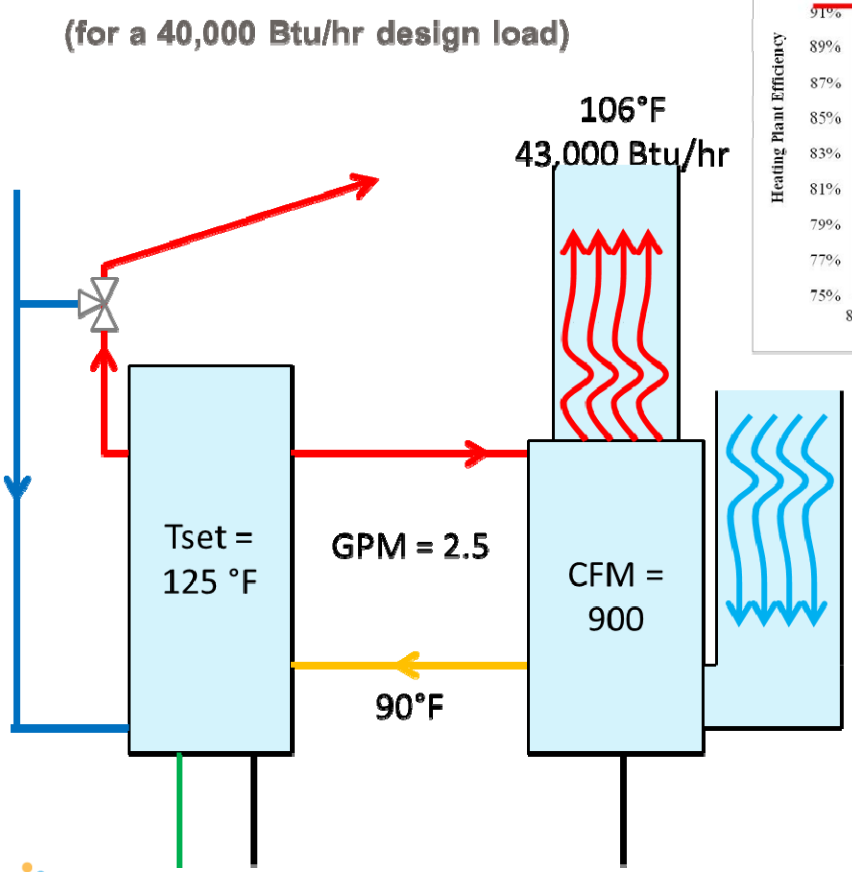
# No Optimization

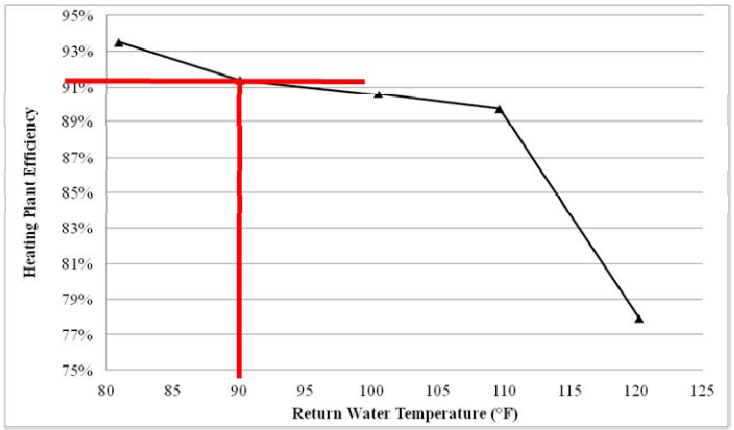
(for a 40,000 Btu/hr design load)



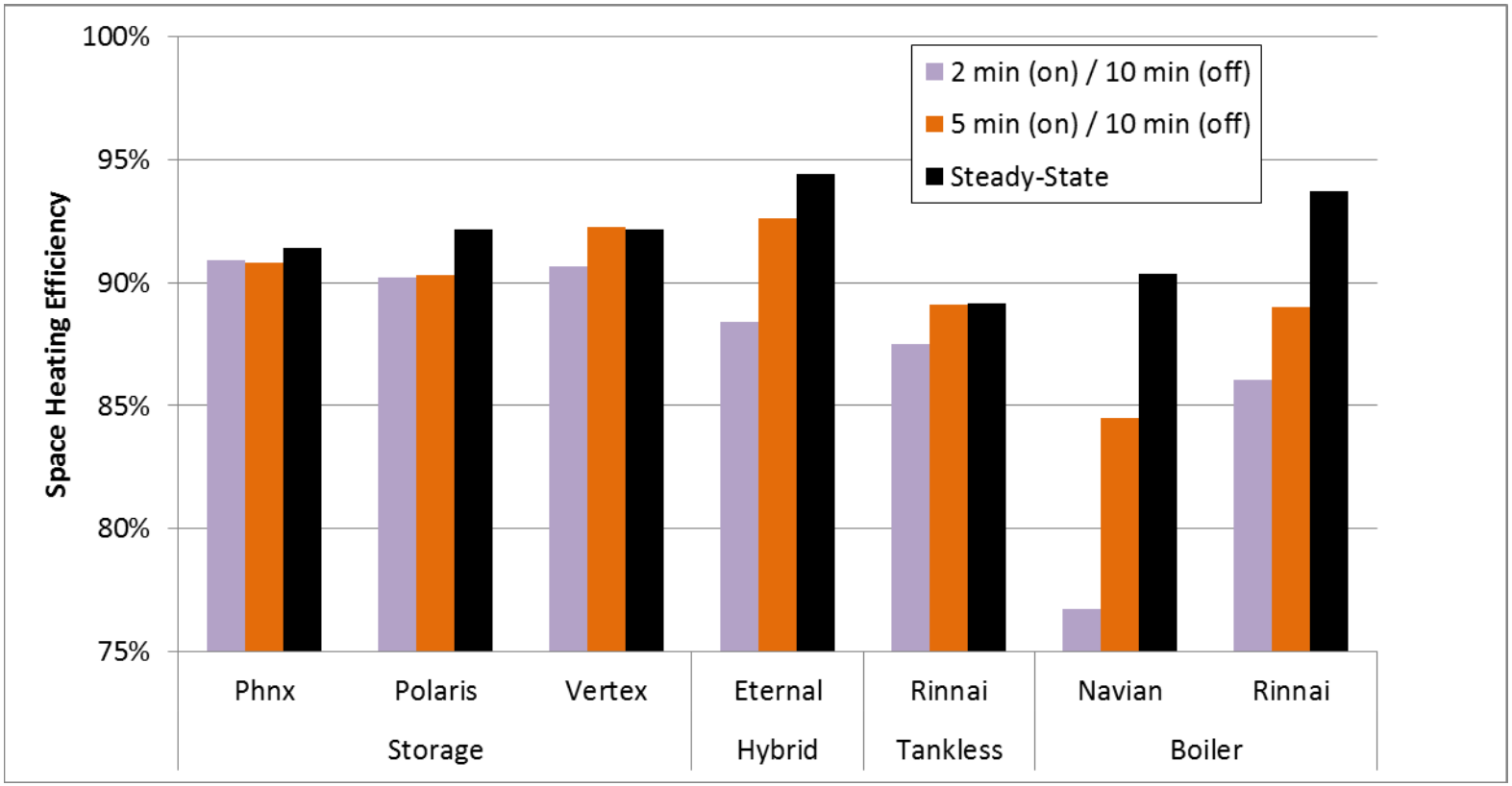



# Fully Optimized



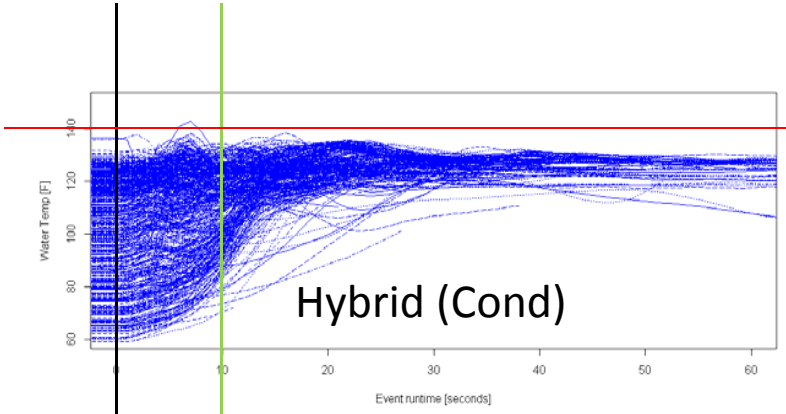
# Right Sizing

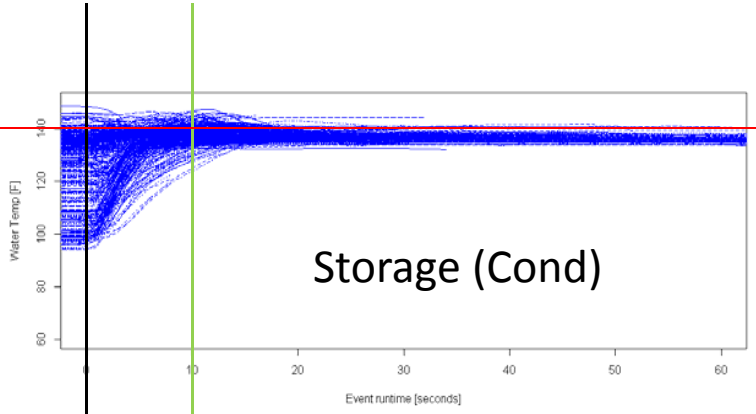


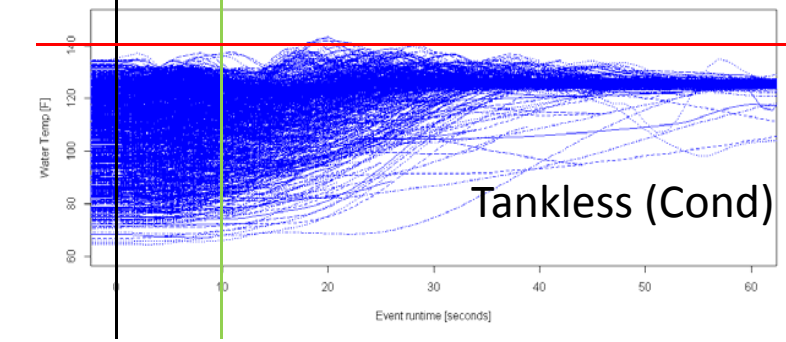
# Occupant Experience

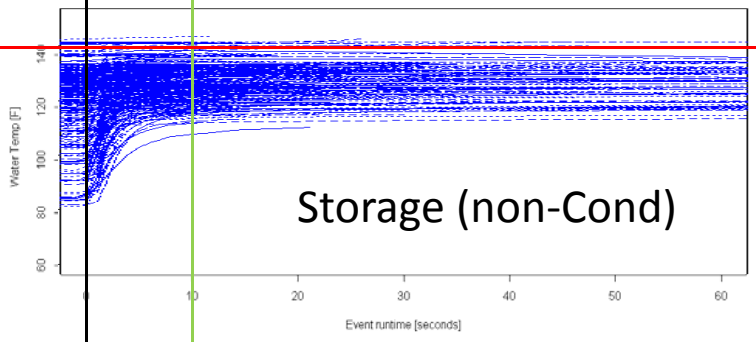
- Changes to:
  - Water Delivery
  - Air Delivery

# Water Temperature Delivery

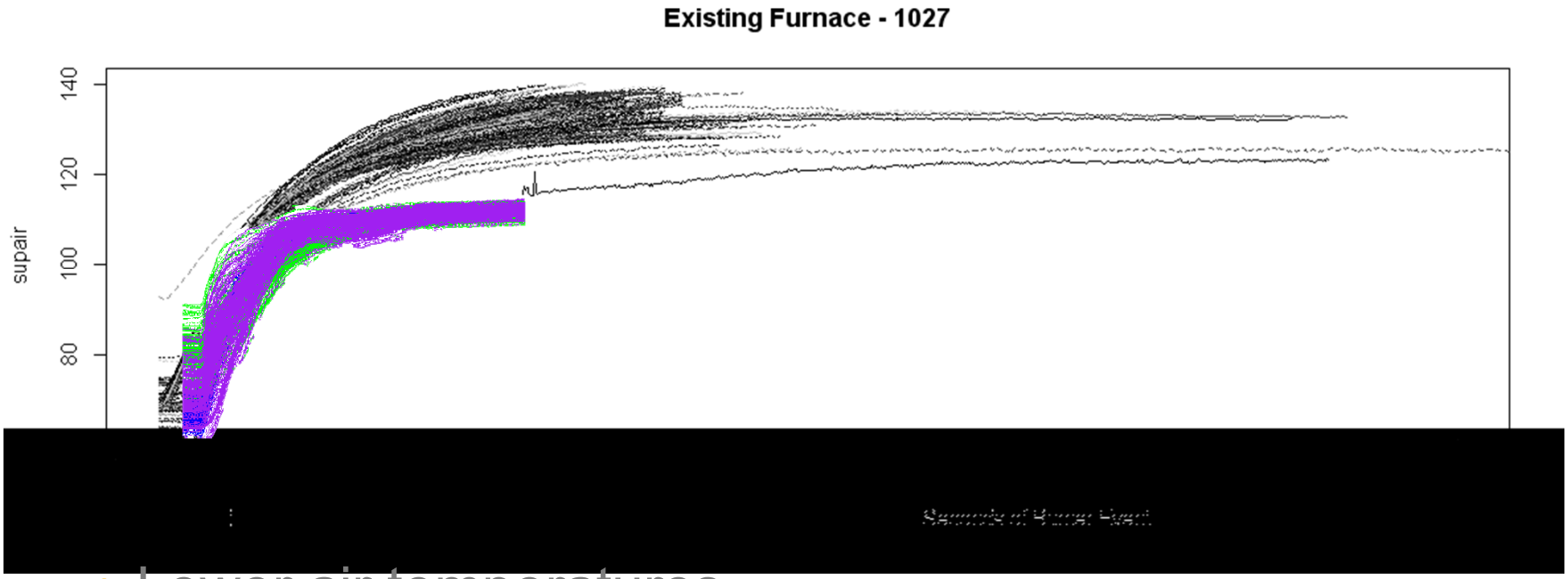


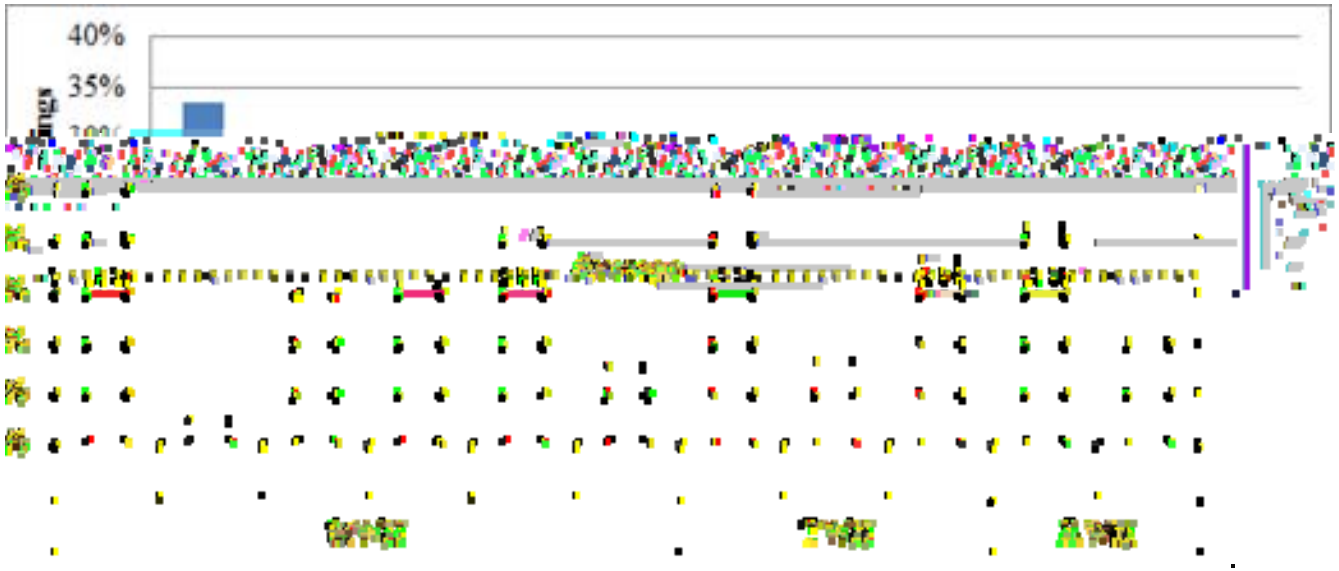



# Delivered Air Temperature




- Lower air temperatures
- Longer cycles

# Savings




| Heating Plant | Installed Efficiency | | | Rated Efficiency | |
|---|---|---|---|---|---|
| | Annual | Winter Space Heat | Summer DHW | Rating Method | Rating |
| StWH | 86% | 87% | 60% | Thermal Efficiency | 95% |
| TWH | 86% | 85% | 85% | Energy Factor | 93% |
| HWH | 90% | 92% | 61% | Energy Factor | 95% |
| Existing[1] | 71% | 72% | 47% | AFUE/Energy Factor | 79% / 59% |

# Verification

- 3 Tiers of Verification

| Verification Measures | | | Expected Performance | |
|---|---|---|---|---|
| Approved Equipment | Trained Contractor | Verified Performance | Space Heat | DHW |
| ✓ | | | 80% of Optimal | Optimal |
| ✓ | ✓ | | 90% of Optimal | Optimal |
| ✓ | ✓ | ✓ | Optimal | Optimal |

# Energy Savings Verification

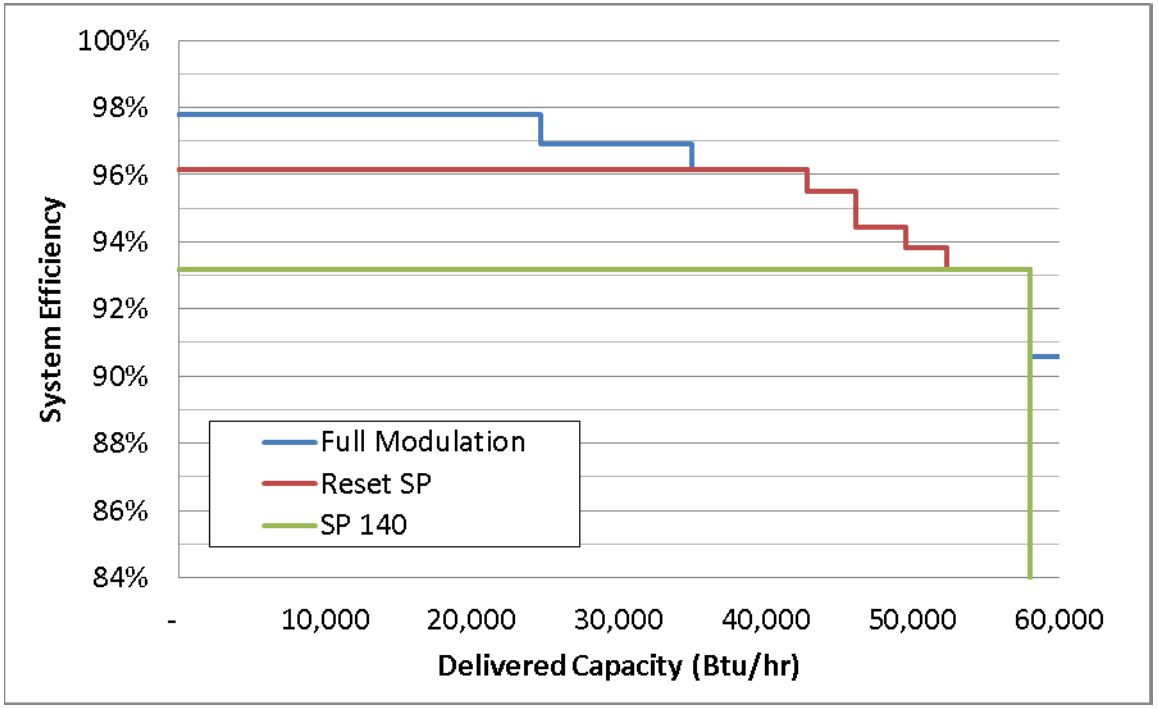
- LIWX agency installed 200+ in Twin Cities metro
- Typically replaced a 80% AFUE furnace and a 0.59 EF water heater
- Trained technician performed system optimization
  - Utility bills showed an median savings of 13%
- Detailed pre/post analysis
- Trained optimization and verification
  - Savings of 16%

# Future

- Total system packages
- Controls
  - Set point reduction

| Site | Heating Plant | Set Point Reduction | Annual Energy Use (therms) | | | |
|---|---|---|---|---|---|---|
| | | | Pre | Post | Savings | |
| 1027 | Polaris | 10 | 809 | 776 | 33 | 4.1% |
| 1031 | Polaris | 5 | 773 | 751 | 22 | 2.8% |
| 1056 | Phoenix | 10 | 551 | 538 | 14 | 2.5% |

  - Full modulation

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# THANK *you!*

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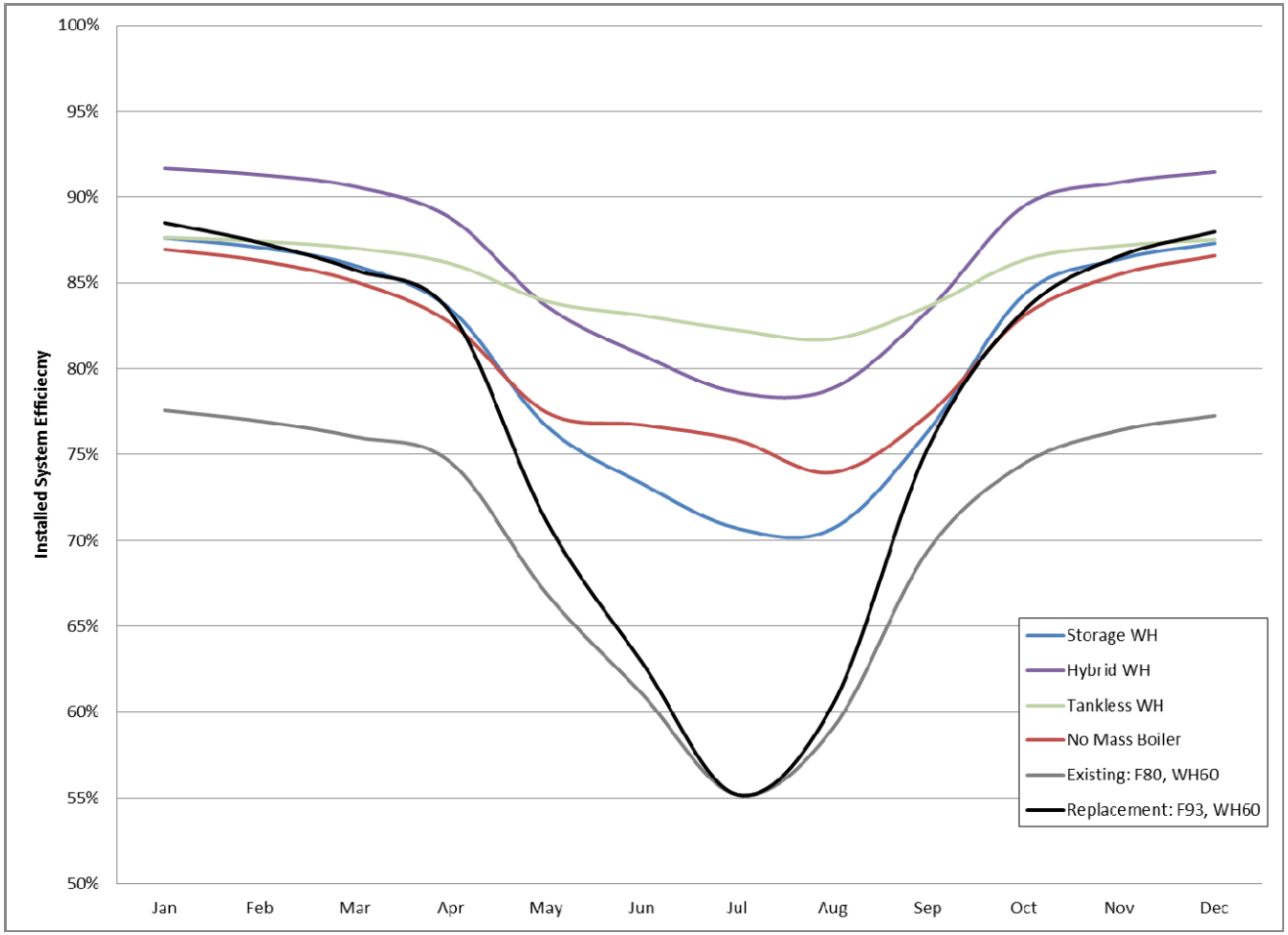
# Installed Performance



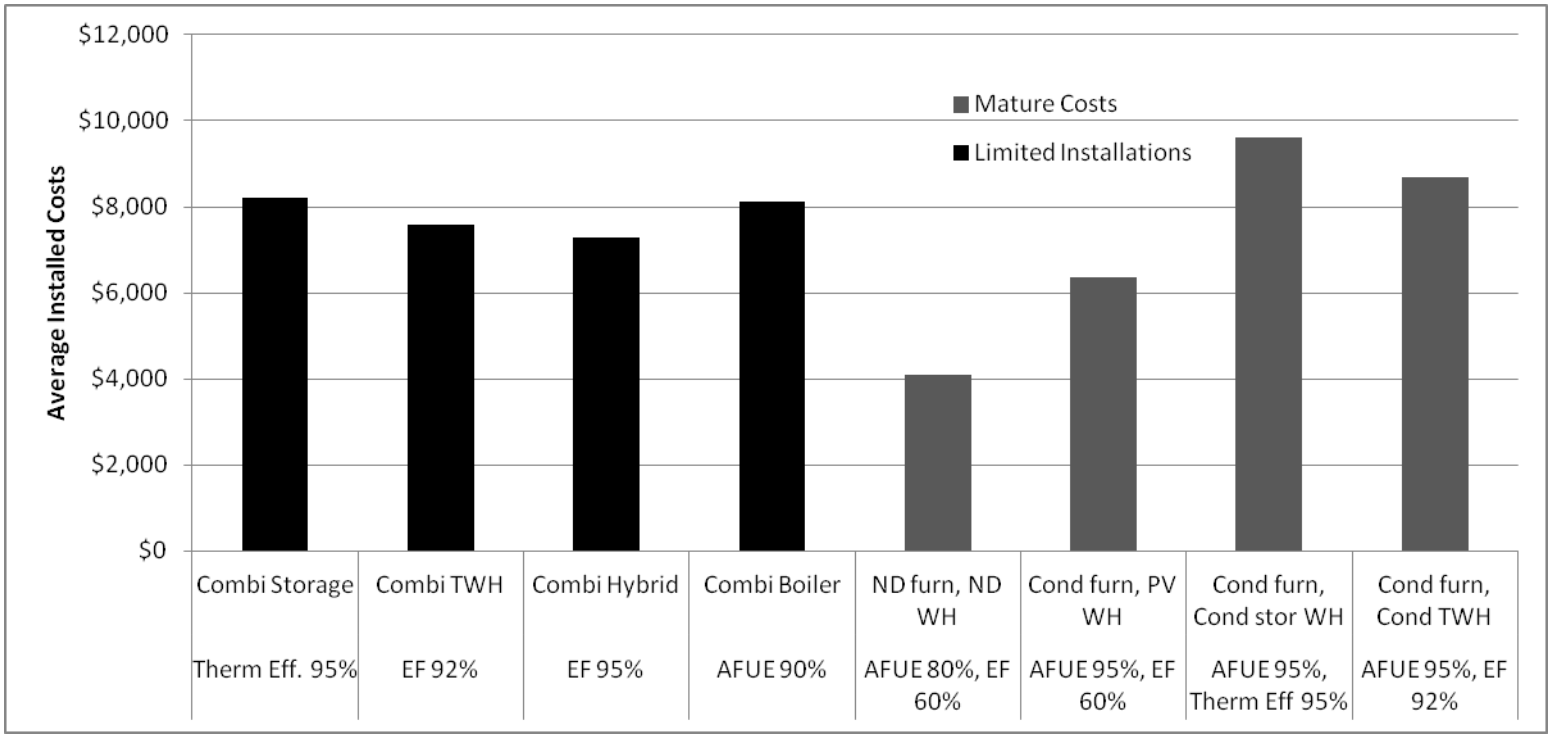
# Lessons Learned

- Assessing the needs of the home and letting that inform the system that is installed
  - number people and showers and how that effects comfort
  - water quality
  - thermostat set points and setbacks
- Code officials
  - ask first, install second!
  - System diagrams

# Lessons Learned

- Having good contractors
  - learning curve
  - Training
- Ensuring quality of installation
  - equipment specific requirements
  - field verification of installation
  - optimization and maintenance

# Cost


$12,000
$10,000
$8,000
$6,000
$4,000
$2,000
$0
Average Installed Costs
Mature Costs
Limited Installations
Combi Storage
Therm Eff. 95%
Combi TWH
EF 92%
Combi Hybrid
EF 95%
Combi Boiler
AFUE 90%
ND furn, ND WH
AFUE 80%, EF 60%
Cond furn, PV WH
AFUE 95%, EF 60%
Cond furn, Cond stor WH
AFUE 95%, Therm Eff 95%
Cond furn, Cond TWH
AFUE 95%, EF 92%

# Utility Billing Analysis