BA-PIRC

2014 Building Technologies Office Peer Review

Tommy Williams Homes; Gainesville, FL; 1st zero energy home by a production builder in the southeastern US

Building AMERICA U.S. Department of Energy

Partnership for Improved Residential Construction

BA-PIRC

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

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Florida Solar Energy Center

Building America Project Summary

Timeline:

Start date: January 2013

Planned end date: January 2015

(BA Teams operate on a CY timeline though funded with FY funding, this review includes FY13 & FY14)

Key Milestones (general BA project milestones)

1. Project Planning and Go/No-Go; previous Q3 – Q4
2. Detailed Project Test Planning & Review; Q2
3. Project Execution and Ongoing Evaluation; Q2 - Q4
4. Reporting and Communication; Q1 subsequent

Budget:

FY13 DOE $: $7,200k for all 10 BA industry partnerships (average $720k per team excluding cost share)

FY14 DOE $: $8,135k for all 10 BA industry partnerships (average $814k per team excluding cost share)

Total future DOE $: TBD (program up for re-solicitation)

Target Market/Audience:

Residential building industry stakeholders - developers and builders, architects, contractors, utilities and other program developers with focus on "above code" market actors.

BA-PIRC Key Partners:

Subcontractors Washington State Univ. Northwest Energy Works Florida H.E.R.O.	NSP recipients, local governments & housing authorities
	Habitat for Humanity
Utilities Florida Power and Light FL Natural Gas Assn. Tacoma Power	Small Production Bldrs
	Natl. Labs (PNNL, LBL)
	Product Manufacturers

Project Goal:

Develop and demonstrate **market-ready** building solutions that improve the energy efficiency of new and existing homes, with increasing comfort, health, safety, and durability. Conduct research with manufacturing and building partners to verify performance of new equipment/technology and aid in the advancement of newer, better, more cost-effective options. When fully deployed, proven solutions would reduce building-related energy use by **30 percent and 25 percent, respectively, in new and existing residential building stock by 2020, and 50 percent and 40 percent by 2030.**

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Building America Purpose and Objectives

Problem Statement:
Home building and remodeling markets do not invest enough in a continuous improvement process with a focus on innovation or optimization. Research is needed to catalyze the process and enable change by demonstrating risks are negligible or manageable.

Target Market and Audience:
At the individual project level, we focus on the innovators and early adopters that want to distinguish themselves from their competition. At the program level, our audience is all residential building industry stakeholders.

Planned Contribution to Energy Efficiency:
BA program outputs **enable** 30% near-term and 50% long-term source energy savings in new and existing homes. BA teams develop and demonstrate marketable system packages that **reliably** achieve these savings targets. Successful demonstrations are documented and disseminated via technical reports, measure guidelines, the Solution Center, trade journal articles, conference presentations, webinars, and videos.

BA-PIRC Approach

Approach: Work with partners to uncover what is needed to achieve replicable performance at scale, and work directly with stakeholders to achieve that performance.

Key Issues: Demonstrate that achievement of *performance* is key to risk management.

- Performance = Efficiency *and* marketability, affordability, constructability, durability, IAQ, comfort, etc.

Distinctive Characteristics:

- University affiliation provides for budget and deliverable accountability
- Hot humid / Marine climate focus
- Extensive work with affordable housing, including manufactured housing
- FSEC Laboratory capabilities

BA-PIRC Project Integration and Collaboration

Project Integration:

- Performance demonstrated in real homes (*home builders, remodelers, occupants*)
- Select research conducted in concert with *utilities*.
- Select research results fed back to *product manufacturers* (Panasonic, Nest Labs, Carrier, Samsung – ***Energy Star*** Clothes Dryer, etc).
- General results inform ***Energy Star, Challenge Home, Better Buildings Grantees*** and other programs / program implementers / program participants.

Partners, Subcontractors, and Collaborators:

<u>Subcontractors</u> Washington State Univ. Northwest Energy Works Florida H.E.R.O.	NSP recipients (local governments) & housing authorities
	Habitat for Humanity
<u>Utilities</u> Florida Power and Light Tacoma Power FL Natural Gas Assn.	Small Production Bldrs
	Natl. Labs (PNNL, LBL)
	Product Manufacturers

Communications: 24 Published Reports, 20 case studies, 7 solution center content topics, 1 2013 Innovation Award (7 2014 nominations), 23 presentations at national, regional, local conferences, and workshops.

BA-PIRC FY 13 – 14 Tasks (Blue to be discussed in more detail in Reference Slides)

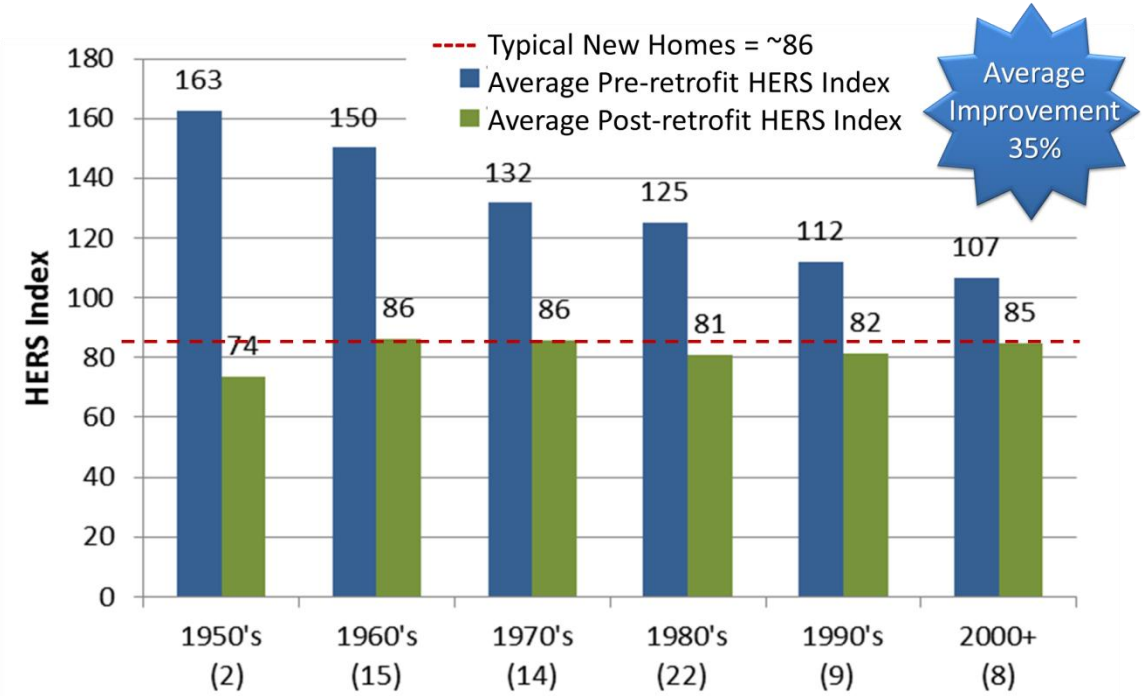
Component Research	• Integrated solutions for variable capacity heat pumps focusing on duct system integration, system sizing, and mechanical ventilation (simulated occupancy lab). • Ductless heat pumps in Marine Climates (8 occupied test homes). • Comparative performance of water heating systems (15 systems tested since 2009 – simulated occupancy lab). • Side-by-side laboratory homes (various experiments). – ventilation/infiltration, moisture buffering, covered/exposed slabs, ducted heat pump water heaters • Relationship of IAQ, comfort, and ventilation in Hot Humid Climates (10 occupied test homes). • Temperature based ventilation control (modeling and simulation). • Solutions to "wind washing" in 2-story homes (6 occupied test homes).
	• Pilot demonstration of Phased Deep Retrofits (60 retrofits of occupied homes).
Homes and Communities	• Implementing "zero energy ready" performance at the community scale (2 interior duct strategies, 3 Challenge Home prototypes and 2 established communities). • Pacific Northwest high performance manufactured home (4 occupied test homes). • Scalability of high performance residential retrofits (70 initial retrofits of foreclosed homes with 10 program partners, 4 new program partners).

BA-PIRC Progress and Accomplishments

Discoveries	• Need for Master Retrofit specifications / 30% best practices for retrofit program implementers. • Experiences with improperly wired multi-stage HVAC equipment suggest need for fool proof "plug-and-play" wiring connections. • New EnergyStar clothes dryers may need fault detection modes to insure sufficient dryer vent flow. Eco modes cannot be much longer than standard modes, or takeback may occur. • Central variable capacity heat pumps up to 46% more efficient at minimum capacity vs. nominal capacity, and have a 92% greater runtime than fixed capacity. Suggested need for integrated solutions (equipment + distribution). • Hybrid water heating system combinations are capable of performing at less than 2 kWh/day, with 80% savings over minimum efficient baselines.
Accomplishments, Awards, Recognition	• Transforming local government and utility policy towards retrofits to include efficiency and performance. • Documenting the business case for 30% new construction. • Contributing to market transformation of ductless heat pumps and manufactured housing in the PNW. • Identifying new methods for construction of interior ductwork. • Awarded 2013 Housing Innovation Award for Zero Energy Ready Homes • Habitat Partner awarded 2013 Challenge Home

2013 - Scalability of Efficient Retrofits– Development of Model Retrofit Specifications for Climate Zones 1-2

Starts with 70 House Retrofit Field Study involving 10 Affordable Housing Partners Rehabilitating Foreclosed Housing with Neighborhood Stabilization Act Funds.



86% (36) of deep retrofits positive annual cash flow ($126)

*1950's (n=2) 52%

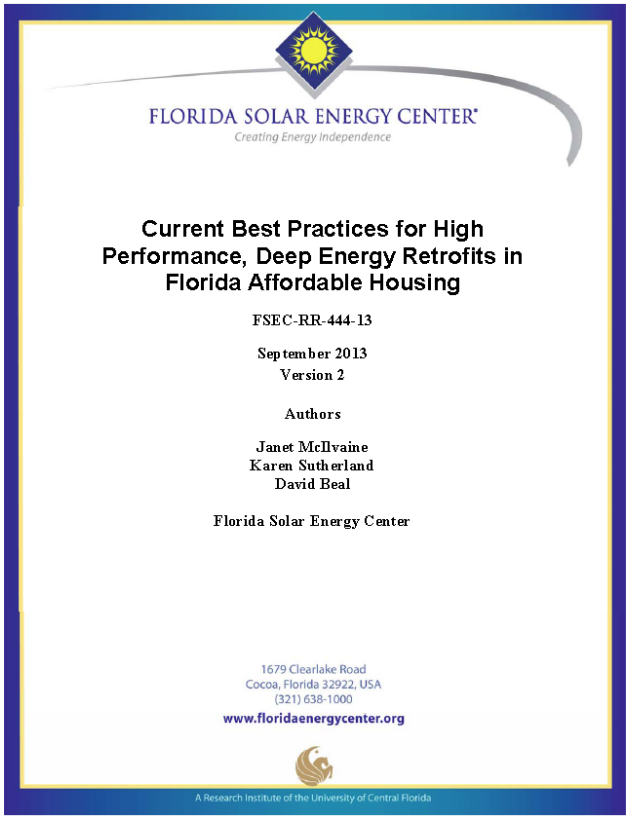
Leads to development of affordable, practical, "Off the Shelf" best practices.

Discovery: To transform standard practice, model specifications are needed and act as a policy tool to guide all future retrofits.

Health, Safety, and Durability Measures (Risk Reduction – all projects):
- Combustion safety
- Whole house pressure balance

Moderately higher performance replacements (for distressed components or end of life equipment):
- Heating & cooling system (SEER 15 heat pump)
- Windows (low-E)
- Water heating (EF 0.92)
- Energy Star lighting, appliances, and ceiling fans
- Light or white exterior finishes
- Meet new construction code for heating and cooling

Efficiency Enhancements (all projects):
- Substantially leak free duct system
- R-38 attic insulation
- Window film
- Air sealing at plumbing and fixtures openings


FLORIDA SOLAR ENERGY CENTER®
Creating Energy Independence

Current Best Practices for High Performance, Deep Energy Retrofits in Florida Affordable Housing

FSEC-RR-444-13

September 2013
Version 2

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Local Government Testimonials

Sueann Thomaston, Grants Administrator, City of Melbourne, Housing & Community Development

"The Building America researchers provided unbiased recommendations and helped us improve our understanding of how to cost-effectively retrofit our homes (in our programs funded by federal and state grants) to achieve high energy efficiency through a scientific approach. They were able to overcome the challenge of using the highest energy efficient solutions while staying within a budget that accounts for homeowners having limited financial resources and a cap on the amount of grant funds eligible for each project. *They helped us revise our minimum rehabilitation standards which are now being used for all our construction projects and specific energy efficient retrofits are being written into each project specification document."*

Diana Giraldo, City of Fort Myers, Community Development Department, Sustainability Coordinator

"BA-PIRC has provided the City of Ft Myers technical assistance on residential energy use which has improved our understanding of how to cost-effectively retrofit our homes with higher energy efficiency and improved safety, comfort, and durability. Through our partnership with BA-PIRC we have developed a new set of "Master Green Specifications" which identifies mandatory improvements for residential rehabilitation contractors. *High performance homes for affordable housing projects in the City of Fort Myers are the new normal thanks to this partnership* and we are pleased to pass on the benefits of these homes to the end users "the homeowners" as well as providing a broad spectrum of knowledge to home building industry with the local contractors that work with us."

Paula Szabo, Housing & Grants Planner, County of Volusia Community Services

"Partnering with Building America has helped Volusia County to change the way we approach retrofits. *We now include higher requirements for HVAC replacements, installation of energy efficient windows and increased insulation into all of our retrofit projects."*

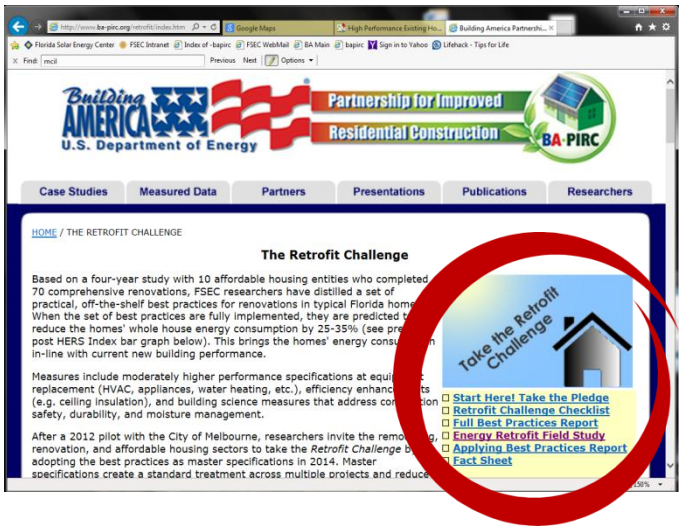
2014 – Development and Promotion of *The Retrofit Challenge*

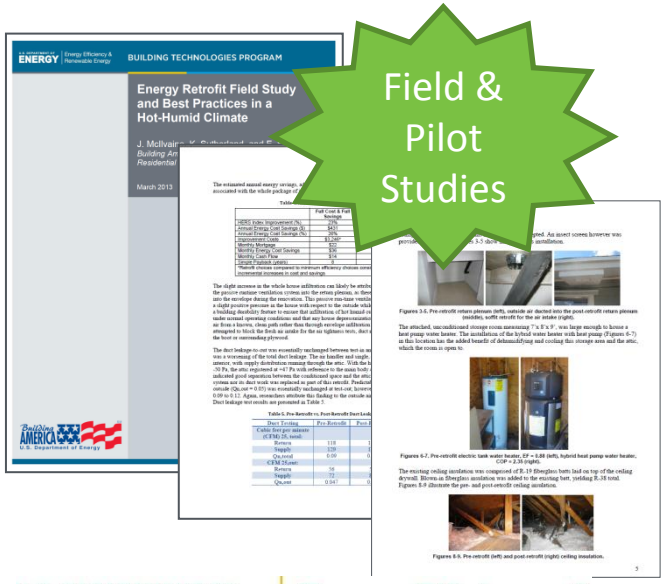
Retrofit Challenge: Partners pledge to use Best Practices within retrofit programs.

Leverages Federally-Funded Research for Regional Benefit

U.S. DOE	U.S. HUD	12 Florida Affordable Housing Entities	*The Retrofit Challenge*
Building America Cost-Shared Research with Industry	*ARRA Neighborhood Stabilization Program*	*70 House Study 46 Deep Energy Retrofits!*	*Best Practices for Existing Affordable Housing (30% Improvement)*

Disseminates Real World Science, Real World Best Practices.





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2014 - *Retrofit Challenge Partners – Committed to 30% Best Practices*

SELF
SOLAR AND ENERGY LOAN FUND

- ***Better Buildings Grantee*** with microloan program.
- As of 12/13 closed 249 loans valued over $2 million.
- Cumulative energy savings > 1 GWh (average home saves 20%).
- Pledged 150 homes to the Retrofit Challenge in FY 14-15.

Habitat for Humanity® of Florida

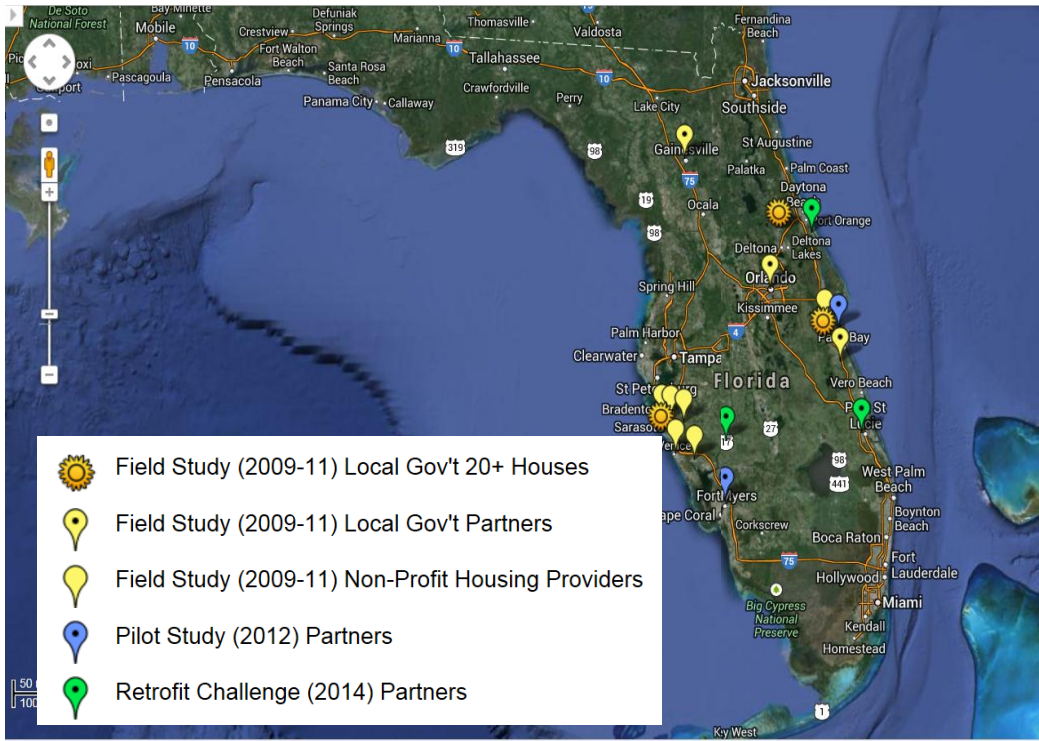
- Administering $20 million in mortgage settlement funds.
- Promoting Retrofit Challenge to all grant recipients.

Southeast Volusia Habitat for Humanity®

Pledging all retrofit projects.

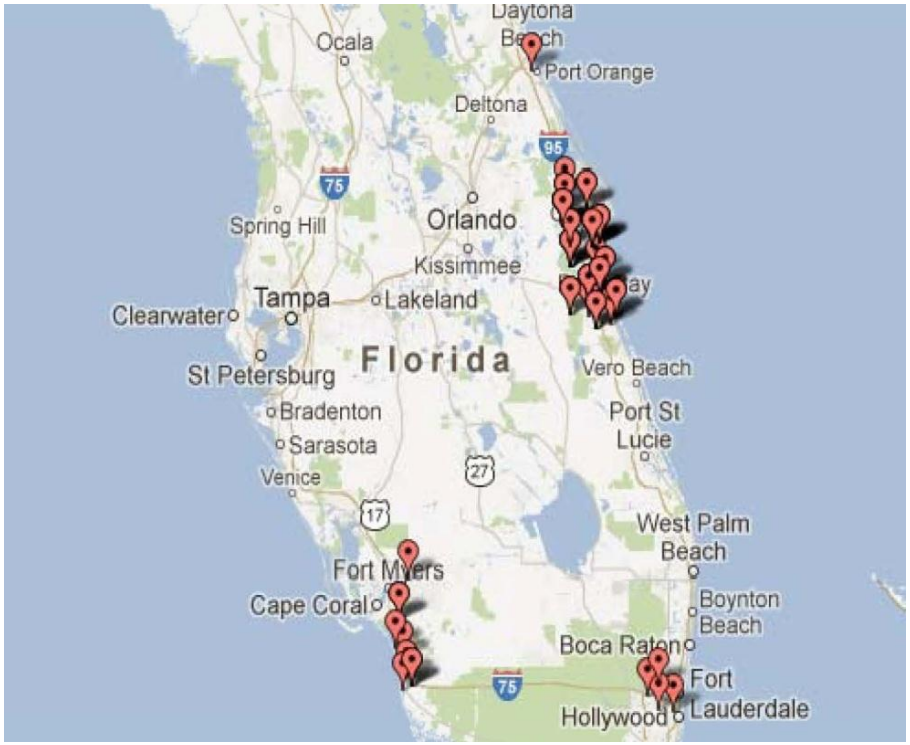
Manatee County Habitat for Humanity®

Pledging all retrofit projects.



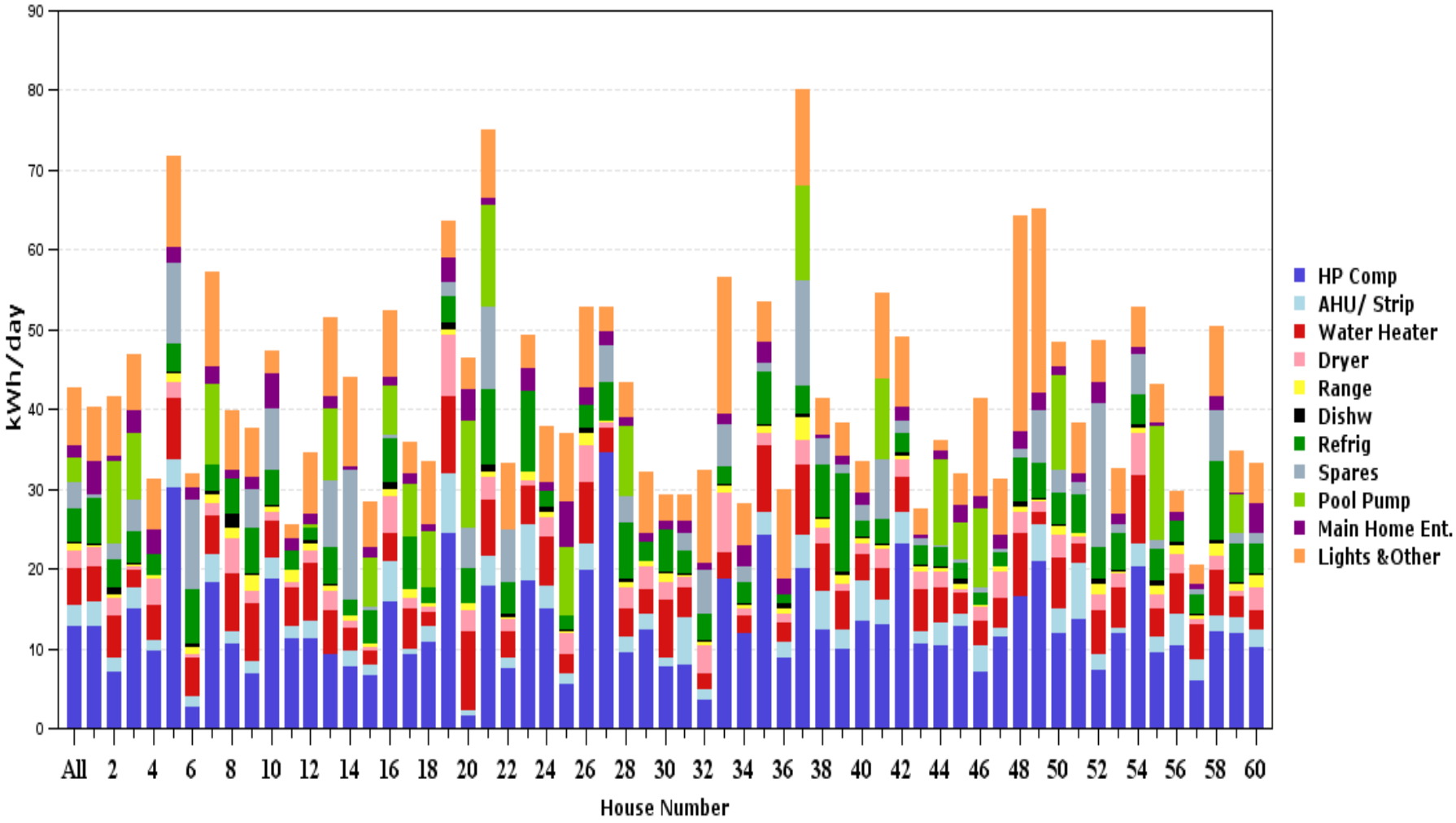
2013 / 2014 - Designing and Scaling > 40% Retrofits- Phased Deep Retrofit (PDR) Project

- Detailed residential field metering project in FPL Service Territory
- Sixty all electric, heavily metered homes audited and monitored since Oct 2012
- Shallow retrofit in all complete by June 2013 & then deep retrofits in 10 recently completed.
- Collecting end use data of value to utilities.
- Demonstrating an approach to utility deployment of whole house retrofits.

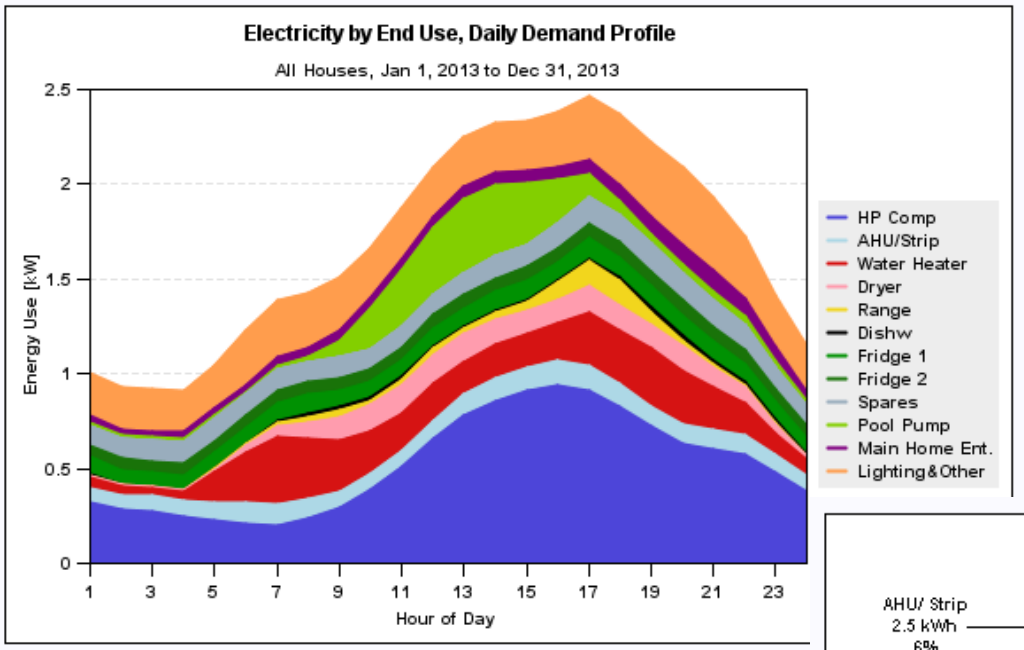


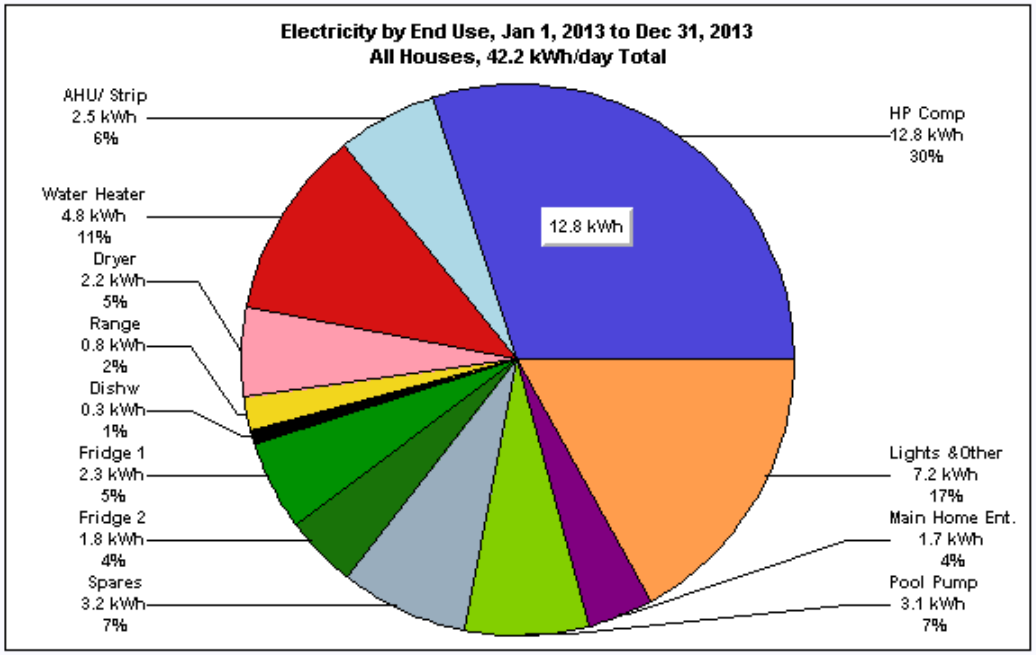
It's Complicated: Mix & Size of End-Uses at Each Site Unique

Average Daily Energy Use for Each Site in 2013



Complex Picture of Electricity Use

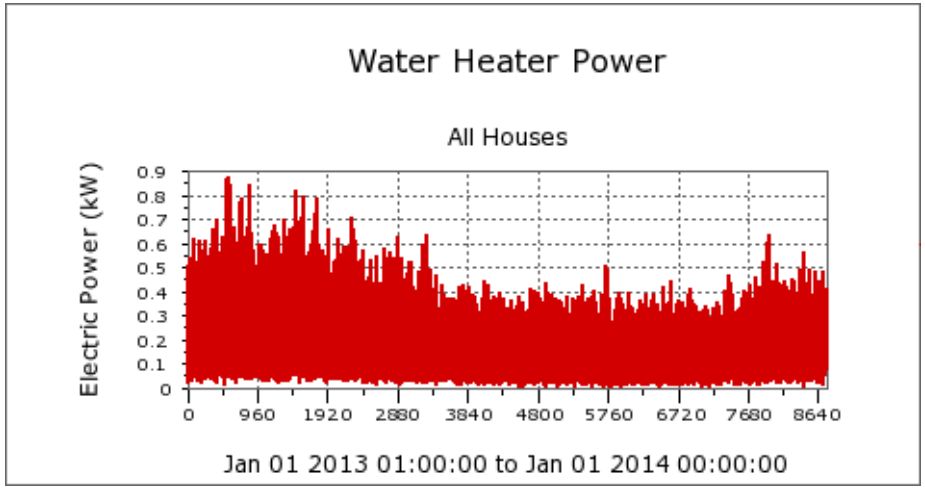




No single end-use dominates; Conventional loads (space heat/cool & water heat) only 45% of total; lighting & plug loads are a large and difficult to address category

Hot Water: Detailed Data on Load Shapes

Hourly

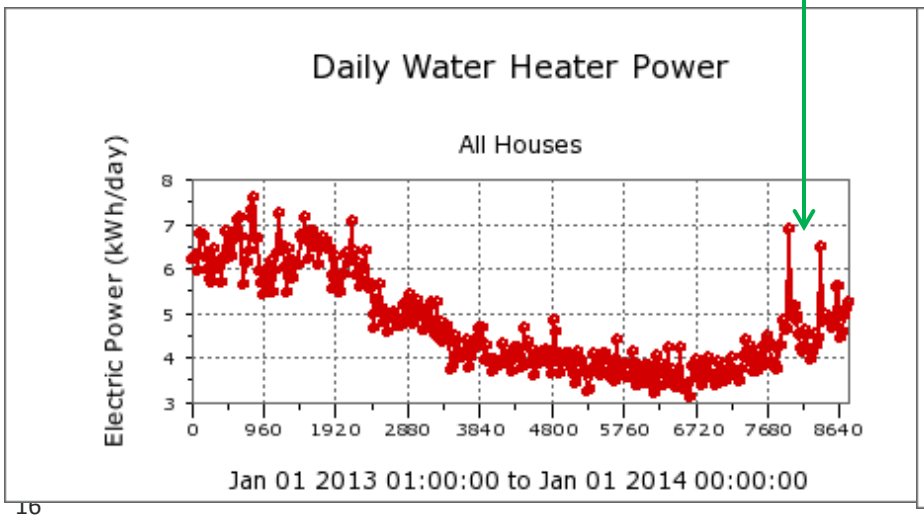


Example: High Quality Water Heating Load Shape Data: Available for Each End Use for an Entire Year

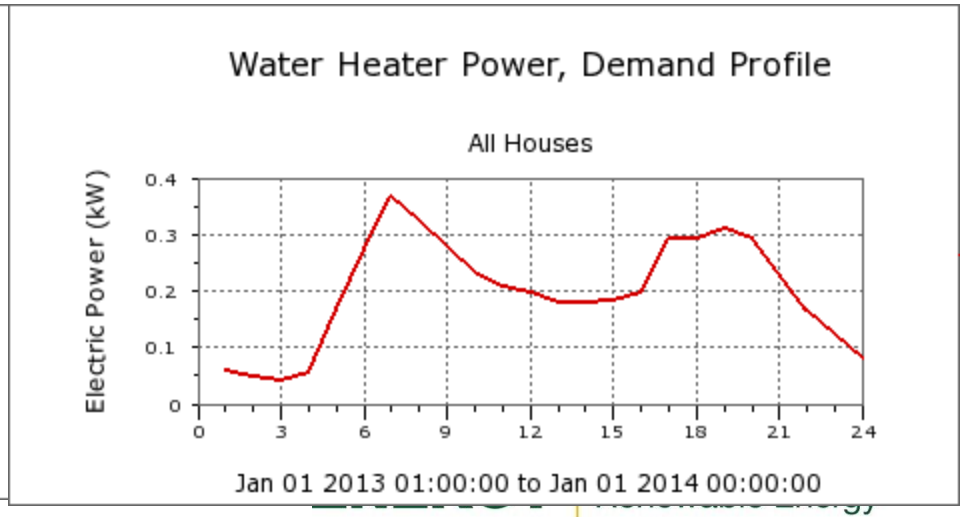
2:1 Difference winter to summer

Daily

Thanksgiving/Christmas

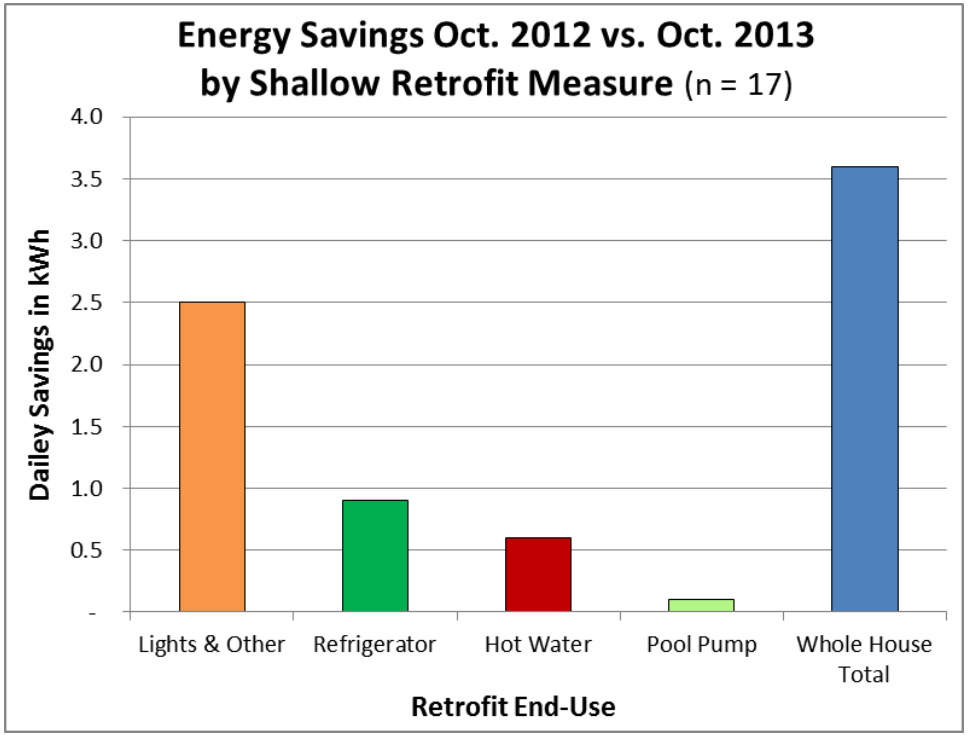


Time of Day



PDR Shallow Retrofits Yield Durable 9% Savings

- Change all incandescent lighting to CFL or LED lighting.
- Add exterior insulation tank wrap to hot water tank.
- Replace shower fixtures with hi-efficiency head if measured flow is greater than 2.2 gpm.
- Set pool pump hours to no more than 5 hours per day.
- Clean refrigerator coils if dirty.
- Provide smart power strip to any standby power loads greater than 10 Watts continuous.
- $370 investment yields $184 annual savings.
- Implication: Simple pass through audits generate savings while allowing collection of detailed audit data.



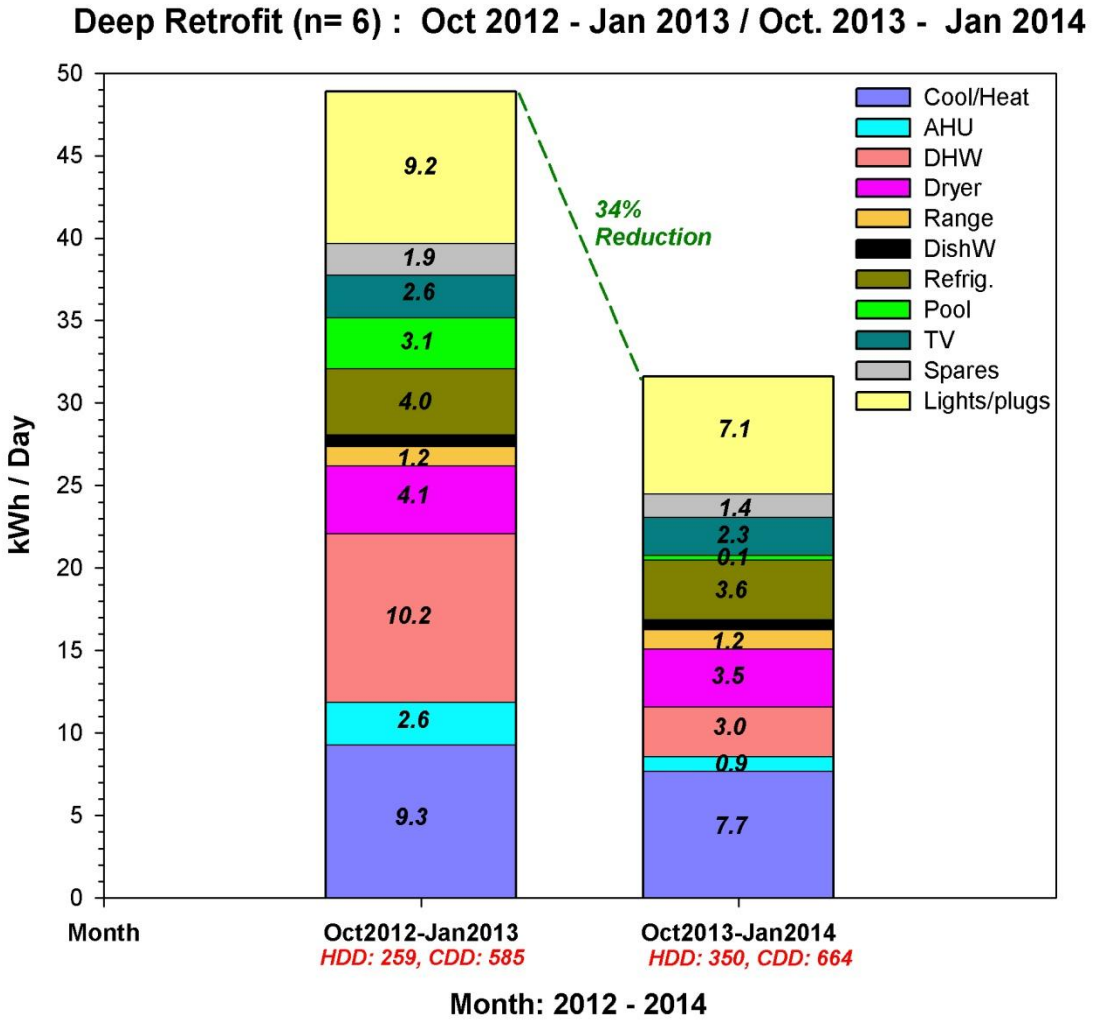
PDR Deep Retrofits – single measure results fed back to product manufacturers

- SEER 16, 2-stage heat pump
- Duct repair targeting < 6 cfm25/100sqft
- Nest Learning Thermostat
- Heat Pump Water Heater
- R-38 ceiling insulation
- ***Energy Star Appliances*** (including clothes dryer)
- Variable Speed Pool Pump
- Air Sealing targeting 5-7 ach50

	• Up to 19% cooling savings in one house • But, negative savings in another through lower temp set point
	• Average 6 month savings in eight sites: 18% (0.6 kWh/Day) • 23% savings in heaviest use site • good load shape reduction potential • some user dissatisfaction
	• 90% savings • huge demand reduction (1.8 kW) • includes pump pad retrofits • needs proper programming to realize savings

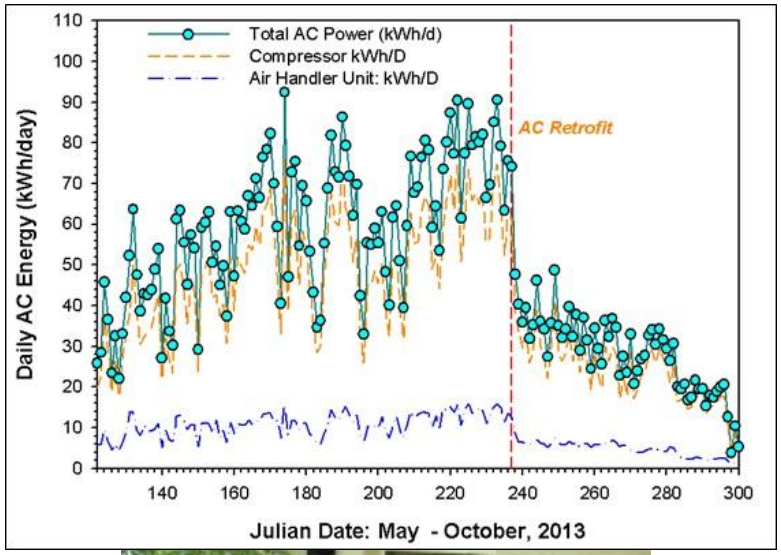
PDR: Early Analysis of Deep Retrofit Savings

- Six retrofits projects
- Compared pre & post
  - Pre: Oct 2012- Jan 2013
  - Post: Oct 2013- Jan 2014
- 34% savings
- Final savings likely ~40%
  - Period does not include energy intensive summer
  - Weather was more harsh in post period (both HDD and CDD)
  - Not all retrofits complete over entire post period



Phased Deep Retrofit Task Potential and 2014 next steps

- Demonstrates shallow retrofit programs effective producing small, very cost effective savings and effective engaging homeowner for larger improvements; gathering data.
- Deep retrofit demonstrated hi-savings levels: 35-40% or greater.
- Highly effective & reliable technologies
  - Large peak demand reductions
  - Noticeable reductions to utility bills
- Immediate results to Florida's largest utility - model for scale-up of effective staged utility programs in Florida and elsewhere.
- Next steps
  - Increase sample size for NEST, Estar dryer and HPWH
  - Mini-split retrofits



2013/2014 - Scaling 30% New Construction Solutions: Habitat for Humanity *Challenge Homes* - collecting technical and economic data

Source Energy Savings
66% with PV 39% without PV
HERS Index
23 with PV 53 w/o PV (CH target = 60)
Incremental Cost = $7,800

Source Energy Savings
38%
HERS Index
49 (CH target = 59)
Incremental Cost = $3,000

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Applying to Production Builders (> 100 homes per year)

Discovery: Implementation of systems engineered efficiency as standard practice (vs. as an option) is key to sustained success.

Cost effective, Zero Energy Ready Performance

	Tommy Williams Homes (Gainesville, FL)	Lifestyle Homes (Melbourne, FL)
Source Energy Savings	31%	30%
Incremental Cost	$3,318	$6,610
Annual Cash Flow[1]	$226	$161

[1] Homeowner annual *savings* over regional standard practice after adding incremental cost to 30yr Mortgage at 5%.

Scaling 30% Savings - Making the Business Case with Market Statistics

Tommy Williams Homes (Gainesville, FL) Vs. competing builder	Lifestyle Homes (Melbourne, FL)
2006 – 40% market share 2012 – 84% market share	2009 – 2013: sales have quadrupled (25 vs. 120 closings)
9 ZEH since 2010	15 ZEH since 2010
Standard product resells at $23,000 resale premium at 92 DOM* vs. 240 DOM*	Both partnerships resulted in DOE Top Innovation Award for *Zero Energy Ready Homes*

"We experienced instant consumer acceptance of these revolutionary energy efficient homes. At a time when home builders where going out of business because of the great recession we were not only surviving, we were prospering all thanks to FSEC." - *Jake Luhn, Lifestyle Homes.*

*** Days on Market – based on 18 Tommy Williams Homes vs. 13 competitor homes**

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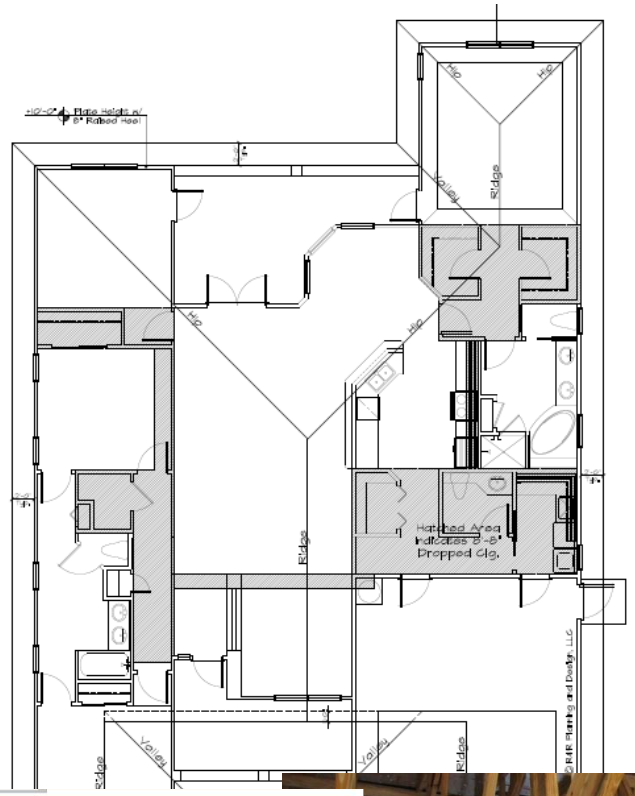
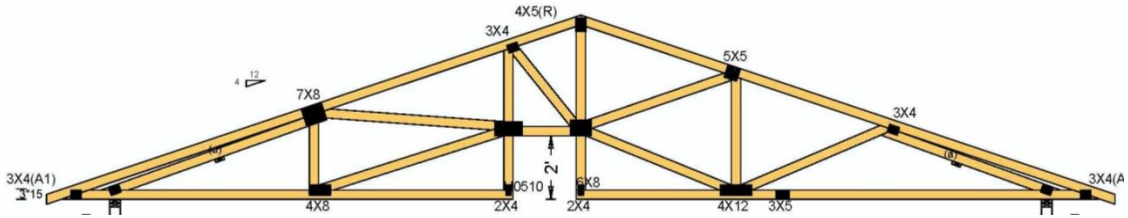
30% Market Transformation in other sectors

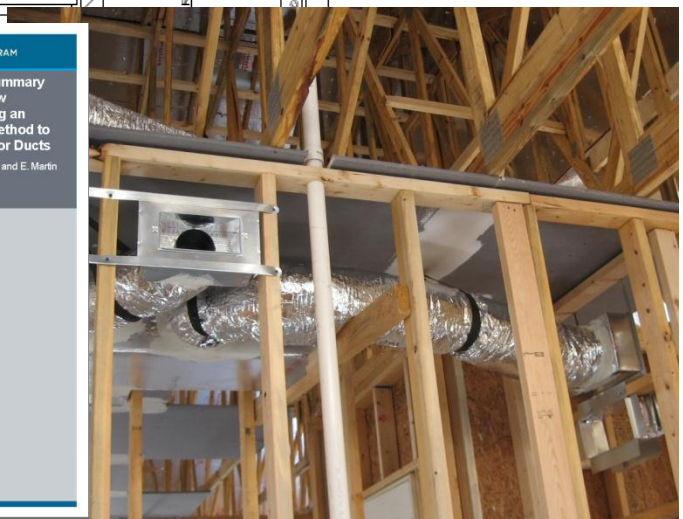
- Hot Humid Multifamily – Atlantic Housing
  - Income qualified rental communities
  - Average 41% savings, HERS 53
  - Over 1,500 units in 16 properties
  - Interest began with performance, now driven by reduced utility allowances.

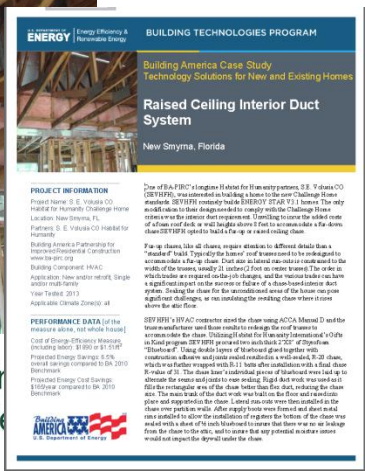
- Cold / Marine Manufactured Housing
  - Researching 40-50% whole house savings
  - Transforms base home to 15% more efficient than code (1,100 homes in 2013)
  - Voluntary middle ground (NEEM) 30-35% more efficient than code (55+% of market 1,300 homes in 2013)

Scaling 30% Savings Key Issue – Interior Ducts: developing and documenting cost effective methodologies









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2013 / 2014 - Low Load HVAC Solutions for 50% Savings- Characterization of Variable Capacity SEER 21 Heat Pump

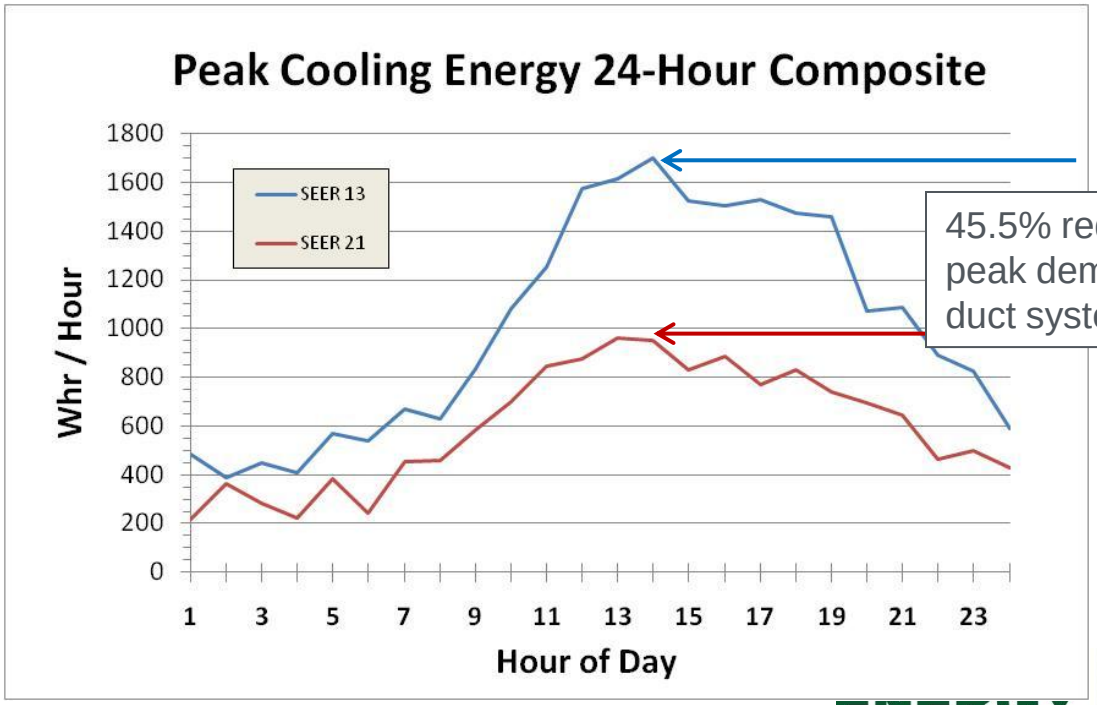
- New generation heat pump with variable compressor (15-60 Hz) enabling variable capacity of 40-118% of nominal.
- Extended runtime (typical day: 65-70% vs. 30-35%) increases thermal and leakage losses in ductwork vs. fixed capacity.
- Implementation requires integrated solutions.

FSEC Manufactured Housing Laboratory Experimental Configuration

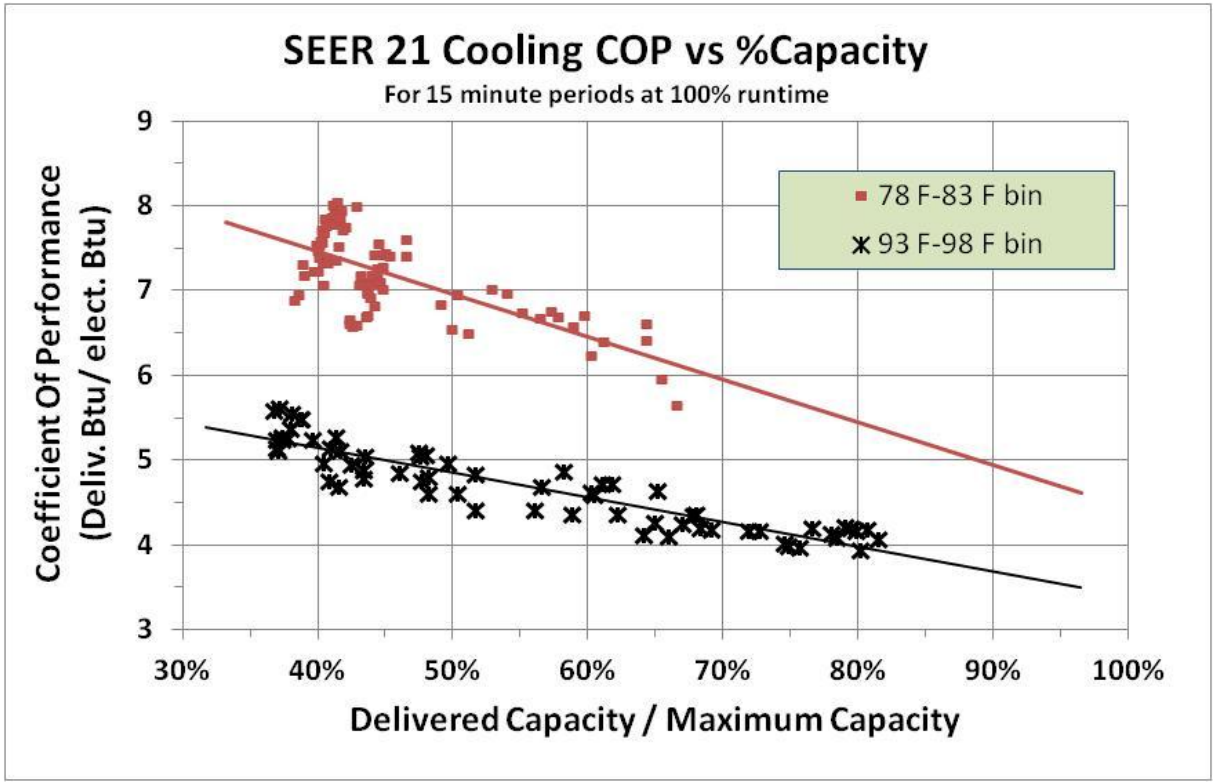
Integrated Solution: Impact of duct configuration on system performance

Discovery: Interior ducts even more important with variable capacity systems.

		Seasonal Energy Savings (Typical Day)		Peak Demand Savings	
		SEER 21	SEER 13	SEER 21	SEER 13
Attic to indoor ducts	Cooling	16.8%	11.2%	38.8%	14%
	Heating	16.7%	10.8%	14%	12.3%



Integrated Solution: Impact of "Right Sizing"



- Documentation of integrated solutions is expected to affect large scale design and implementation guidance via ACCA, etc.
- 2014 focus includes comparison of performance to mini-splits.

Discovery: Variable capacity system 46% more efficient at minimum capacity vs. nominal!
Integrated Solution: Oversizing leads to better efficiency with no reduction in performance.

MH Lab Design Cooling Load Attic Ducts no Leaks	% over sizing with 2-Ton system	% over sizing with 3-Ton system	Seasonal Energy Savings w/ 3 Ton vs. 2 Ton (Typical Day)	Peak Demand Savings
21,000 Btu/h	10%	67%	8%	15.7%

2013 / 2014 - Low Load HVAC Solutions for 50% Savings - Ductless Heat Pumps, Pacific Northwest

Salishan Townhomes (91 units, phase 7)
Tacoma Housing Authority

The Woods – 30 units
Tacoma HFH, TPU, BPA

- NEEA leads successful market transformation effort displacing electric resistance heat with DHP – over 16,000 units installed so far.
- BA-PIRC partner WSU conducting research leading to integrated solutions for new construction and renovation.

Next Steps and Future Plans

- **Develop Measure Guideline / Solution Center content detailing integrated solutions for variable capacity heat pumps**

- **Update BA knowledgebase on mechanical ventilation in hot humid climate, and continue temperature based ventilation control work to pave the way towards acceptance of such strategies in ASHRAE 62.2.**

- **Updating of NEEM specs to prepare regional industry for updated HUD code.**

- **Continue technical and programmatic expansion of retrofits on a large scale**
  - component solutions and packages leading to 50% savings
  - integrating with additional utility, Better Buildings, and Home Performance with Energy Star programs

Summary

- Relevance to BTO needs and objectives
  - Many BAPIRC tasks achieve BA Program efficiency targets ahead of schedule
- Approach/Project Management
  - University affiliation provides budget and deliverable accountability
  - Component/package/prototype/community approach provides go/no-go structure
- Progress, Accomplishments, and Impact
  - Enabling and demonstrating transformation of standard practice in several housing sectors, both new construction and retrofit
    - Single family, multifamily, factory built, low income
  - Collecting detailed component level data leading to greater levels of savings and performance
- Project Integration and Collaborations
  - Better Buildings, Energy Star, Challenge Home, utilities, product manufacturers, local governments, national laboratories
- Next Steps and Future Plans
  - Continue to scale up the technical and market impact of our work.

Project Budget

Project Budget: Building America is a multi-year research program. FY13 and FY14 face-value contract amounts have been summarized here (excluding overhead burden and management).
Variances: Budgets are executed as planned.
Cost to Date: Projects are accrued linearly and managed on a calendar year cycle. For FY14, approximately 30% of project cost has been accrued.
Additional Funding: All BA team contracts have at least 20% cost-share from industry partners.

Budget History					
January 2013 – FY2013 (past)		FY2014 (current)		FY2015 (planned)	
DOE	Cost-share	DOE	Cost-share	DOE	Cost-share
$7,200k	20%	$8,135k	20%	TBD	TBD

Project Plan and Schedule

Building America Team Project Planning and Execution:

- BA teams are funded under a multi-year Task Ordering Agreement managed by NREL. Project portfolios are selected on an annual basis. 2014 is the final year of this agreement.
- All BA Teams go through rigorous annual project proposal and review process, including review and coordination by NREL technical and DOE program management.
- Each project has the following deliverables: detailed test plan, report, case study and BA Solution Center content. Test plans are reviewed by technical program managers and all other publications undergo a peer review process before being communicated to the broader residential industry.