

What Saves Energy & Why: US Program Measured Results

Energy Retrofits For Houses

PROG 6

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Measured Savings?

- ▶ Reliable energy savings info is not easy to find
 - Many programs don't ever get evaluated
 - Many evaluations aren't very reliable
 - ▶ Often don't actually include energy usage data, just projections and surveys
 - ▶ Many evaluators are clueless about energy and not so great with statistics either
 - ▶ It's hard to tell the difference between good and bad evaluations, especially when the jargon starts flying
 - ▶ Low income weatherization programs provide one of the best sources for decent evaluations but results represent older homes in worse condition than typical

How much do retrofit programs save?

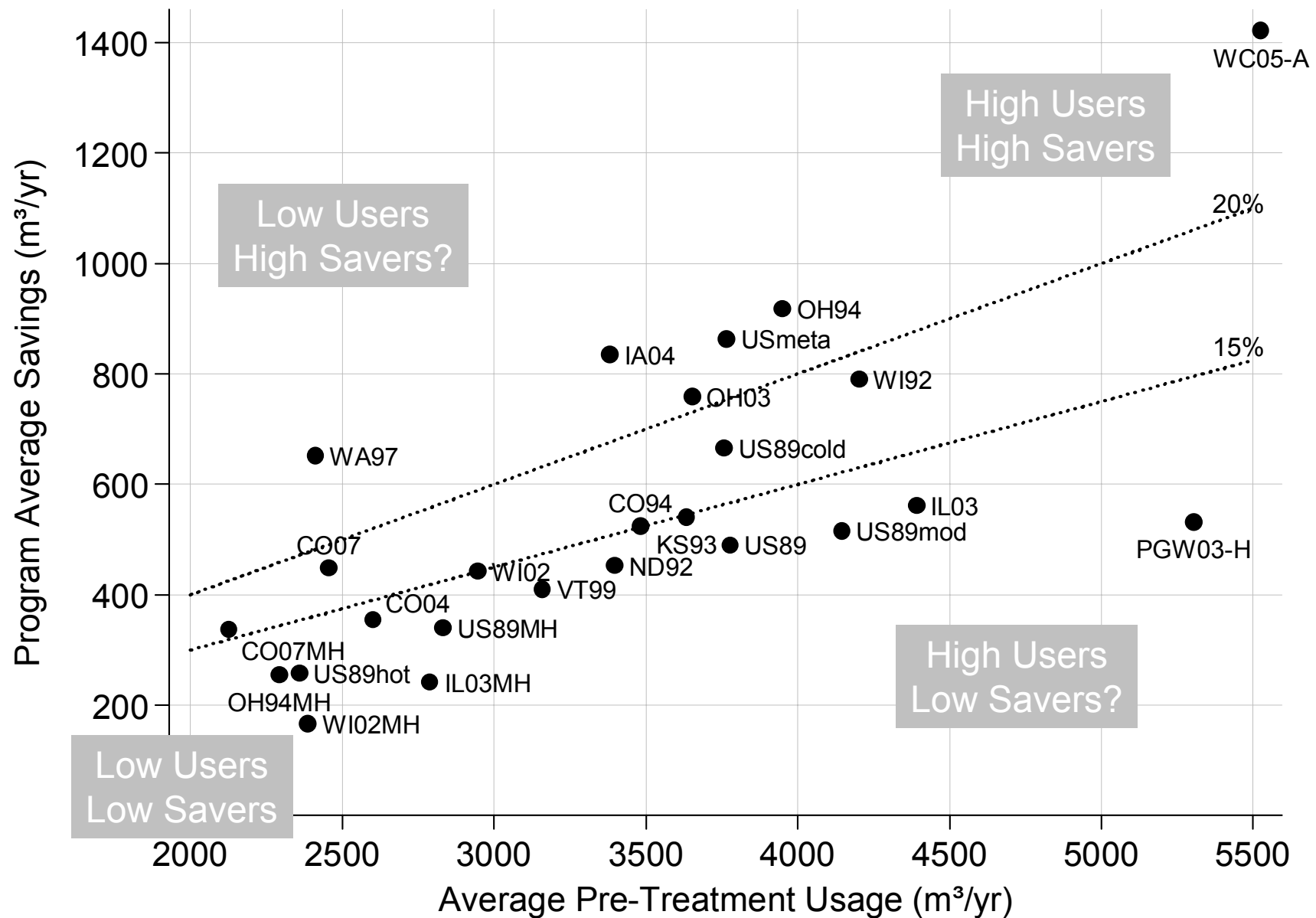
► Evaluation Results

- Many evaluations find about 15% savings, 350 – 600 m³/yr
- Some gov't Wx programs save 25%, 850 m³
- Utility program savings average from 150 to 1400 m³/yr
- Electric baseload programs save 500 – 1,700 kWh

► Why do savings vary?

- Savings come from stopping waste
- High Usage = More waste = More savings
 - Gas use: Low <2000 m³/yr, High >4000 m³/yr
 - Rule of thumb: highest winter bill ~ heating savings potential
 - Electric use depends on end uses: Low <6000, High >10000 kWh/yr if gas HW
- Diagnostic approach identifies the real opportunities
 - computers can help sell jobs, but aren't needed to pick most retrofits
- Proven treatments capture the savings, if done right

US Wx Program Evaluation Results



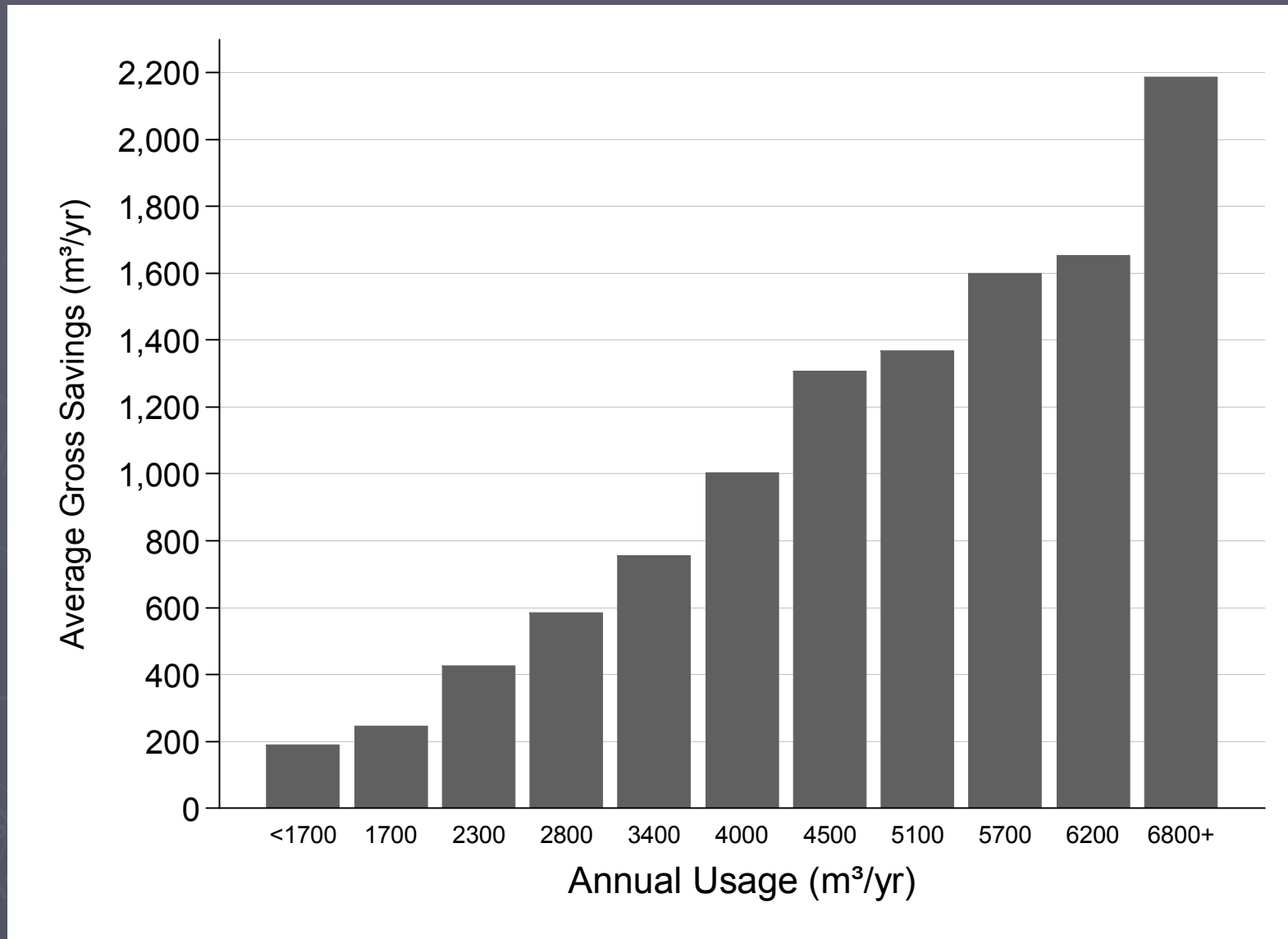
Wx Gas Savings Results

average m³/year/home

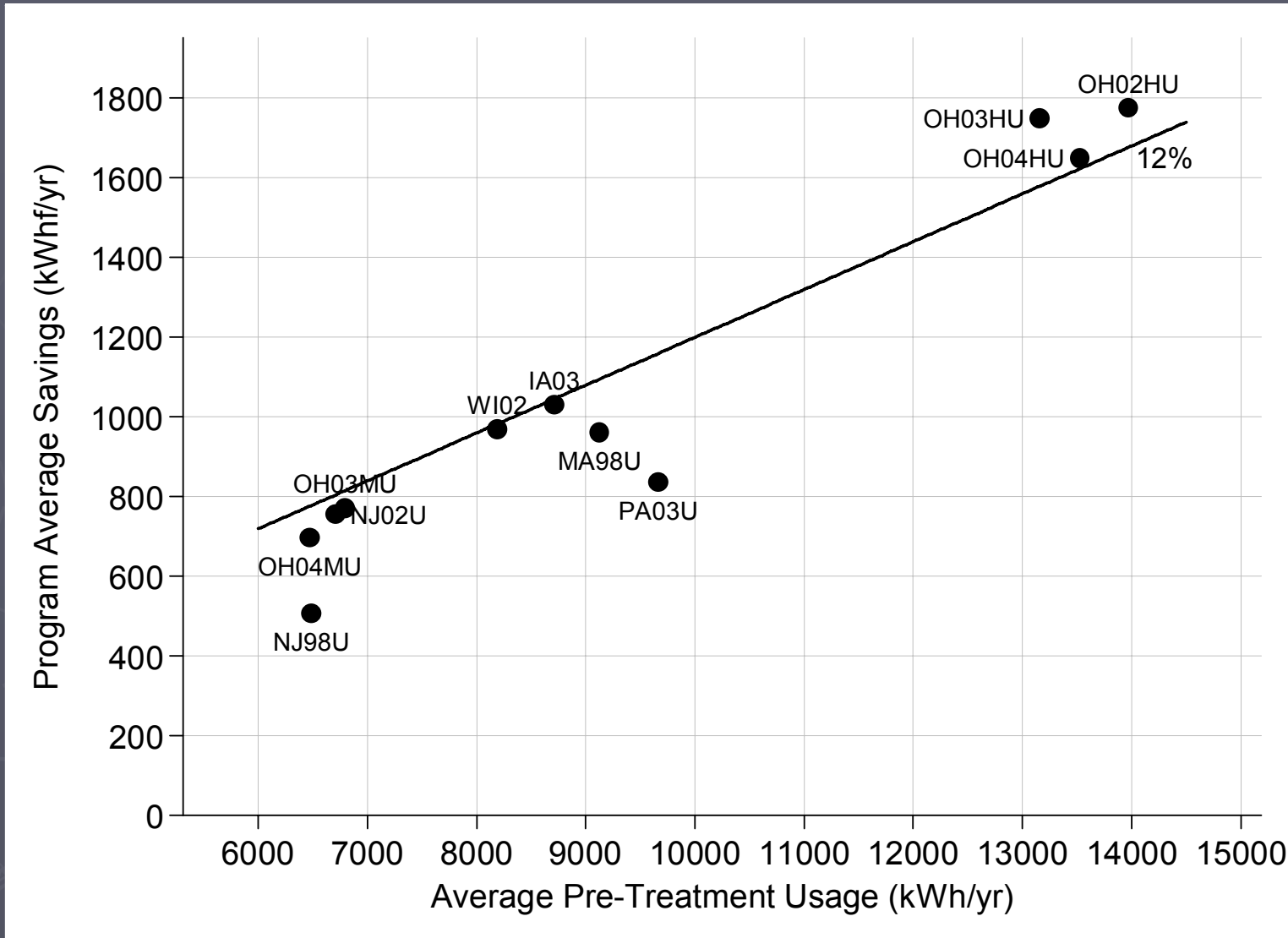
Study	Year	# Units	Usage	Savings	Save%	Cost \$/job
National: All	1989	3,873	3,777	490	13%	\$1,550
National: Cold	1989	1,040	3,758	665	18%	
Nat'l Meta-eval	'93-'03	n/a	3,766	864	23%	\$2,913
Ohio	1994	2,209	3,950	917	23%	\$2,547
Iowa	2004	633	3,381	835	25%	\$5,682
New Hampshire	2005	27	3,630	784	22%	\$4,253
Ohio	2003	1,625	3,653	759	21%	\$4,800
Washington	1997	71	2,413	651	27%	\$3,132
Illinois	2003	2,056	4,392	561	13%	\$4,337
Kansas	1993	165	3,633	541	15%	
Colorado	1994	3,431	3,483	524	15%	
Colorado	2007	977	2,455	447	18%	\$3,309
Wisconsin	2003	8,252	2,945	442	15%	\$6,800
Vermont	2000	25	3,160	411	13%	\$3,227
Colorado	2004	1,557	2,602	354	14%	\$2,850
Col Gas PA: Cont 1	2005	108	5524	1421	26%	\$5,626
Phila Gas: Cont 2	2003	671	5304	532	10%	\$816

Energy Savings vs. Usage

Ohio WAP 94



Electric Baseload Program Evaluation Results



Baseload Electric Savings

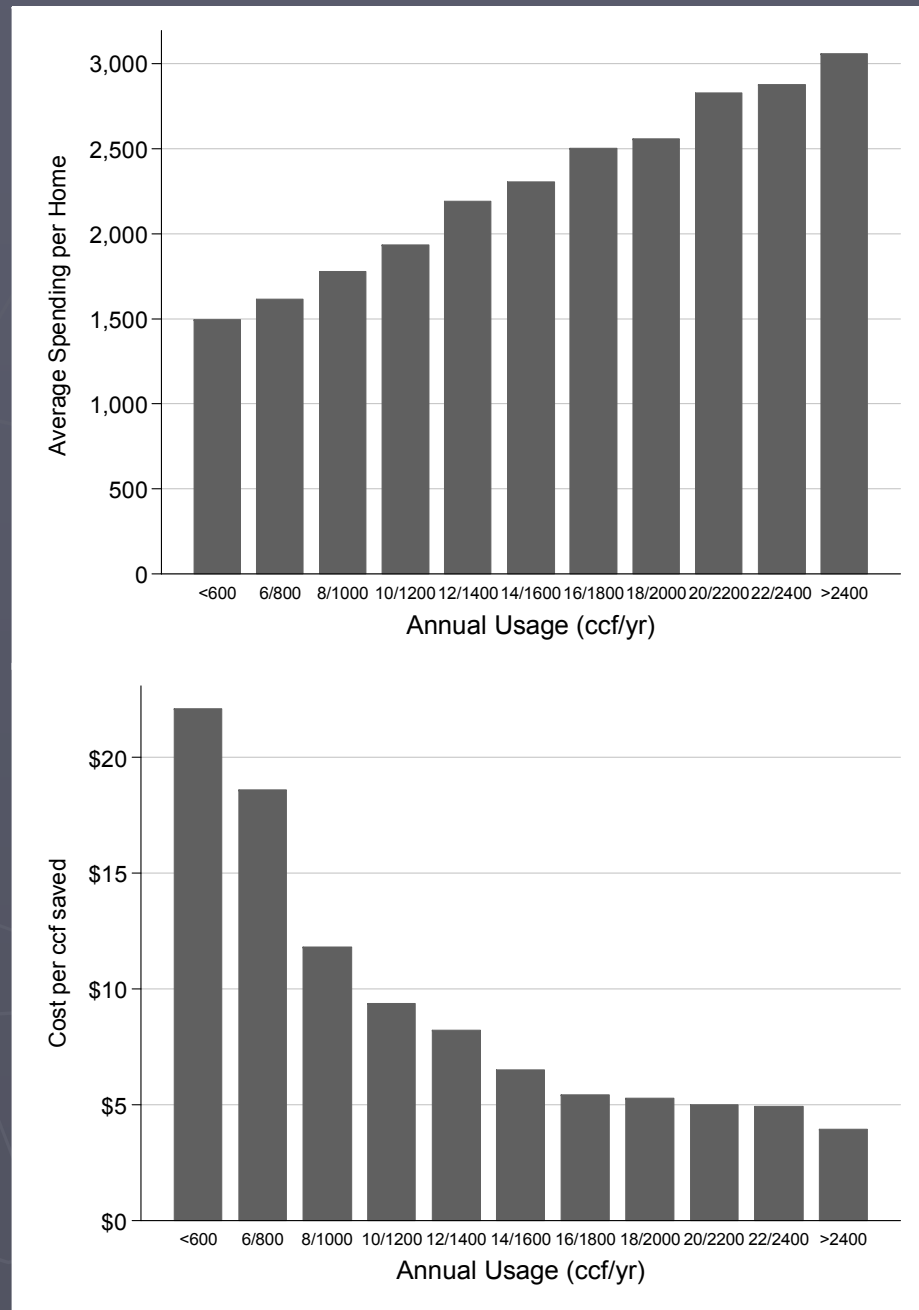
usage and savings in kWh/year/home

Study	Year	# Units	Pre-Use	Savings	Save%
Ohio HiUse	2004	4,789	13,525	1,650	12%
Ohio HiUse	2003	4,525	13,159	1,750	13%
Ohio HiUse	2002	2,194	13,975	1,775	13%
Ohio ModUse	2004	1,355	6,468	697	11%
Ohio ModUse	2003	2,585	6,791	772	11%
Iowa	2003	294	8,711	1,031	12%
Wisconsin	'01-'03	8,675	8,191	970	12%
MA utility	1998	~2,000	9,125	962	11%
NJ Utility	2002	756	6,705	756	11%
PA Utility	2003	659	9,661	836	9%

- ▶ Savings ~ 12%, but varies 772-1750 kWh depending on usage
- ▶ Payback generally quicker than most gas heating measures
- ▶ Refrigerators, lighting produce most of savings, except some hot water (and fuel switching in WI)

Usage & Cost Effectiveness

- ▶ Spending increases sharply with usage in diagnostically driven programs
 - Spending doubled from lowest to highest users
- ▶ High users much more cost effective
 - Cost per ccf saved dropped dramatically



Finding Energy Waste

- ▶ Lack of efficiency measures - install them
 - Insulate walls and attics
- ▶ Inefficient Stuff - replace
 - Heating system, refrigerator
- ▶ Extra Stuff - unplug it / remove it / turn it off / control it
 - 2nd fridge, freezer, humidifier, all night outdoor lighting
 - Harder to deal with: swimming pool, aquarium, grow lights
- ▶ Defects - find and fix
 - High air leakage rate with lots of attic bypasses
 - Thermal/Pressure Boundary Issues
 - ▶ split level, kneewall, porch, balloon framing
 - Hot water leaks
- ▶ Behavior -educate
 - Thermostat settings, lack of setback
 - Leave stuff on 24 hours/day: lights, computers, TVs, fans, furnace fan

Things that work: Thermal Envelope

▶ Wall Insulation

- Big savings if uninsulated walls: $\sim 0.6 \text{ m}^3/\text{ft}^2/\text{yr}$ (350-600 m^3/yr)
 - ▶ Usually most cost-effective major retrofit
 - ▶ but savings often about half of software projections
 - ▶ Dense-packing approach & QC (with IR) help ensure savings

▶ Attic Insulation

- Save $\sim 0.3 - 0.6 \text{ m}^3/\text{ft}^2/\text{yr}$ (150-420 m^3/yr)
 - ▶ Savings vary with existing R-value and bypass leakage rate and fixes

▶ Air Sealing with a blower door

- Savings potential depends on existing leakage
- Savings 18 $\text{m}^3/\text{yr}/100\text{cfm}50$, or 35-70 $\text{m}^3/\text{yr}/\text{ACH}50$
 - ▶ savings vary with climate, locations sealed, and house size (if ACH)
 - ▶ 80 – 300 m^3/yr total, depending mostly on leakage reduction
 - ▶ About 50%-70% of standard projected savings due to infiltration algorithm errors and interactions with conduction

Things that work: HVAC

- ▶ Heating System Replacement
 - Save 250-600 m³/yr (12%-20% of heating)
 - ▶ 92%+ AFUE provides ~20%+ savings vs. older systems
 - Existing system efficiency better estimated at about 75%
 - ▶ Cost-effective only in high use homes (>3000-4000 m³/yr)
- ▶ Seal & Insulate Ducts in attics, garages, crawlspaces
 - 6%-20% HVAC savings potential if people are dumb enough to put ducts in these places (i.e., U.S.)
- ▶ Set-back Thermostats?
 - 3%-7% savings (100-300 m³/yr) found in some program evaluations
 - ▶ Target to homes that actually want them
 - ▶ Saves most in homes that don't consistently practice manual setback
 - ▶ Do savings last?

Things That Work: Hot Water

- ▶ Fix Hot Water Leaks
- ▶ High Efficiency Clothes Washer
 - Save ~ 800 kWh (100 m³) and 11,000 gals water vs. old units
 - Save ~ 300 kWh (35m³) and 7,000 gals vs. std. new units
 - ▶ savings depend on HW and dryer fuels, assumes 1 load/day
 - Cost-effective retrofit if high utility costs or high laundry use
 - Or...you can just wash clothes in cold or warm more often
 - ▶ Save 350 kwh (15 th) per year if 50% cut in hot water use
- ▶ Very Low Flow Showerheads
 - most showerheads low flow, but 1.6 gpm units may save ~ 30 m³/yr
- ▶ Tankless Gas Water Heater Retrofit ???
 - Save ~ 200 m³/yr
 - ▶ but high cost (~\$2500) means 30+ year payback
 - Tankless units operate below rated EF, also performance issues
 - ▶ tank units also perform below rated EF if HW use < test value

Things That Work: Electric Baseload

- ▶ Replace inefficient refrigerators
 - Based on rated usage or short term (1-2 hr) metering
 - Save ~600-900 kWh/yr, up to 2,000 kWh if 1970's side-by-side
- ▶ Lighting
 - CFLs & Fluorescent fixtures save 20-50 kWh/bulb/yr
 - ▶ savings < predicted: removal, burnout, hours of use, still cost-effective
 - Motion detectors, especially all night outdoor lighting
- ▶ Remove/unplug/shut off unneeded stuff
 - Furnace/AC air handler set to "On" can cost 3,000 kWh/yr !
 - Secondary fridges, freezers can use 400-2000 kWh/yr
 - 24 hour stuff: Computers, lights, TVs, fans, etc.
 - ▶ Can waste 100-500 kWh/yr each
 - ▶ Often no real benefits – misinformed occupants
 - Vampire / Phantom / Standby loads
 - ▶ Not really huge, but growing, use (smart) power strips

Things That Work: If Diagnosed

- ▶ Advanced air sealing, strategic dense packing and stuff you learn about at this conference
 - Use blower door, infra-red, zonal pressures, etc.
 - Problems common in split levels, kneewalls, cantilevers, porch connections, balloon framing, McMansions
 - Often addresses comfort, moisture, IAQ and other problems
- ▶ Air conditioner tune up
 - Save 5%-12% of cooling use? maybe if done right?
- ▶ Duct balancing / pressure relief MAD-AIR
 - More common problem in tighter new homes
 - limited savings data

Things that don't save enough (1)

▶ Window replacements

- Savings ~ 5-10 m³/yr/window, often 100+ year payback
- Somewhat better savings if:
 - ▶ Single windows without storms, jalousies
 - ▶ Storm windows more cost-effective, but people like windows

▶ Routine Weatherstripping & Caulking

- Savings ~ 0-40 m³/yr
- Most air leakage is in attic, basement, key junctures

▶ Floor Insulation

- Fairly costly retrofit with low savings
 - ▶ Ducts, equipment, and thermal regain effects
 - ▶ Basement ceiling insulation may save nothing
 - ▶ Crawlspace: Savings 0 – 110 m³/yr (<.15 m³/ft²)
 - must fix ducts, try conditioned crawl instead?

Things that don't save enough (2)

- ▶ Heating System Tune-ups
 - Gas: 0 savings
 - ▶ Some savings if big problems
 - ▶ OK for safety, don't need very often
 - Oil more likely to benefit, savings still questionable
- ▶ Basement Duct Sealing
 - Savings = 1%-3% found in several studies
 - ▶ maybe more if basement is hottest room in winter, fix big holes
 - Might be needed for health/safety if dP problem
- ▶ Energy Feedback Devices?
 - Poor evaluations, wishful thinking
 - Newer studies not finding measurable savings
- ▶ Small behavior changes with trivial impacts
 - change furnace filters monthly, clean fridge coils, close fridge quickly, close drapes at night, cook with lids on pots