Residential Energy Efficiency Programs: Lessons Learned

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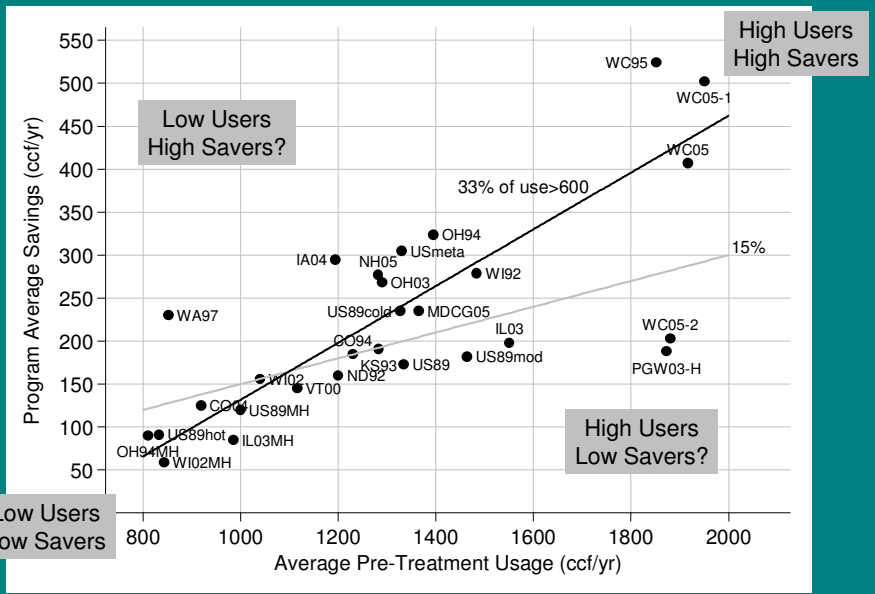
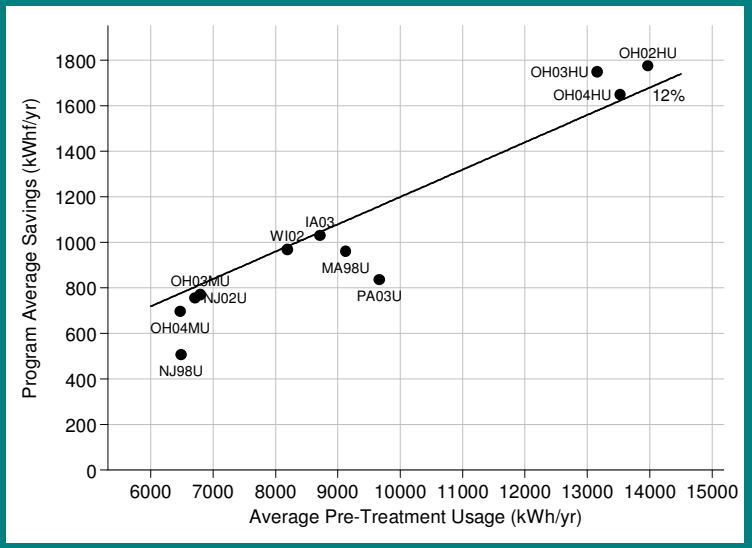
Lessons Learned from Evaluation

- Philosophical
  - All models are wrong, but some are useful
  - It is easy to lie with statistics... but it is easier to lie without them
  - Those who do not learn from history are doomed to repeat it.
- Practical
  - Targeting is key to high energy savings
    - targeting high use homes for treatment
    - identifying the best treatments for each home

Wx Program Evaluation Results



Electric Baseload Program Evaluation Results



Predicted Energy Savings
Track Record

- Evaluations have found only 50%-70% of audit-projected savings (realization rate)
  - NEAT Audit (typical) 50%-60% of projected
    - NC (Sharp 1994) 13.9 of 24.4 MMBtu, 18 houses
    - NY (Gettings 1998): 53 of 105 MMBtu, 49 high users
    - IA (Dalhoff, 1997): 20.3 vs. 37.3 MMBtu, 42 homes
  - Literature review (Nadel & Keating 1991) found 44% avg. residential realization rate
  - Not just thermal measures
    - OH electric baseload program 58%-68% of projected
    - NJ 2 studies found 60%-69%

How is this knowledge used?

- Some people read the literature: Wx potential study (Schweitzer 2002) adjusted projected savings
  - "actual savings typically amount to about 60 percent of the predicted reduction in energy usage"
- But many evaluators don't read: claim that pre/post usage analysis can't be used or is unreliable
  - Instead, savings claims often based on biased projections
  - Example: recent HP evaluation
    - Did small billing analysis, but kept using 100% projected savings:
      - "Due to the variance in home electric use and savings, the billing analysis results cannot be used to verify or adjust the total electric savings predicted by the ... modeling software"
      - "The billing analysis indicates that the average savings were only 73% of the average reported by the program ... at this time, the results of the billing analysis cannot be used to verify or adjust the modeled gas savings"

Why Are Savings Overestimated?

- Damn Occupants!
  - Easy to blame behavior, but not much evidence of takeback effect, especially for major thermal measures (Nadel, 1993)
  - Behavior can affect individual homes, but shouldn't bias overall results
  - Occupant's do impact measure removal: showerheads, CFLs, T-stats
- Poor Work Quality?
  - Potential factor for measures requiring higher skill levels: insulation, air sealing, duct sealing, and HVAC work can be done poorly
- Savings Projections/Calculations are Poor
  - Biggest reason for shortfall is that projected savings are too high, not that actual savings are too low
  - Poor assumptions and biased inputs
  - Bad algorithms that never get tested and/or never get fixed

Common Projected Savings Flaws

- Assume low existing efficiency
  - if you don't know a quantity, assume the lowest performance
  - assume furnaces are 60% efficient, uninsulated walls and attics are R-3-4, showerheads use 3-5 gallons/minute, etc.
  - assume high heating balance point
- Make biased simplifications
  - ignore interactions between air flow and conduction in cavities
  - underestimate thermal regain from basements and crawlspaces
  - under-estimate or ignore waste heat value in winter
  - ignore many little factors which nearly all indicate lower savings
  - provide false sense of precision by measuring the easily measured
- Don't bother with a "reality check"
  - don't look at actual usage
  - don't apply "fudge" factors developed from prior evaluations

Things That Work: Building Shell

- Insulate uninsulated walls and attics
  - Save about 0.2 th/ft²/yr. in heating climates
  - Partially/poorly insulated attics
    - worth insulating if you also fix bypass leakage problems – saving ~0.1 th/ft²/yr.
- Air seal leaky homes
  - Use blower door to measure and find leaks
  - save 5-8 th/100 CFM50 reduction
  - Often the largest unexploited savings
    - few people know how to do it
- Hot Climates
  - radiant barriers or cool roofs if ducts are in attic
    - save ~10%-20% of cooling load
  - solar control for windows – screens, films, etc.

Things That Work: HVAC

- Turn down thermostat and/or use setback
- Seal ducts in attics, crawlspaces, garages
  - Save 8%-20% of HVAC loads
    - savings highest for attics, lowest for crawlspaces
- Replace Inefficient Heating Systems
  - Usually only cost-effective if high usage
    - Heating use of 1200-1400+ th/yr needed for OK payback
    - Save 20%-25% of heating usage if old 70% ->92%
    - Always select 92%+ furnace if replacing anyway
- Air Conditioners
    - premature replacement rarely cost-effective: only if very high use and very old unit
    - tune-ups – depends on approach and situation...

Things That Work: Hot Water

- Fix Hot Water Leaks
  - Tremendous savings potential when found
- High Efficiency Clothes Washer
  - Save ~ 800 kWh or 35 th and 11,000 gals water vs. old units
  - Save ~ 300 kWh or 12 th and 7,000 gals vs. std. new units
    - savings depend on hot water and dryer fuels, assumes ~1 load/day
  - Cost-effective for premature replacement if
    - high energy or water costs
    - high laundry usage: 2 loads/day or more
  - Or...wash clothes in Cold or Warm more often
    - Save 350 kwh or 15 th per year if 50% cut in hot water use
- Very Low Flow Showerheads
  - most existing showerheads already low flow, so savings may average <10 th, 200 kWh from std. low flow units
  - but 1.5 gpm units may provide better savings, if kept

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 often ~50% projected due to removal, burnout, hours, heat
    - still cost-effective
  - Motion detectors, esp. 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 commissioning / tune up
  - Must measure charge and air flow
  - Save ~ 5%-12% cooling use – worthwhile if big cooling load
    - Usually doesn't help at all if done by typical HVAC contractors
    - Need to test charge and air flow, TXV units may not benefit much
- Duct balancing / pressure relief MAD-AIR
  - More common problem in tighter new homes

Things that don't save enough

- Window replacements:
  - Savings ~ 2-3 th/yr per window, 100+ year payback
- Routine Weatherstripping & Caulking
  - Save ~0-15 th/yr, leakage in attic, basement, junctures
- Floor Insulation: fairly costly with low savings
  - Basements: ??, Crawlspaces: 0 – 40 th/yr (~ .05 th/sq.ft.?)
- Heating System Tune-ups
  - Gas: 0 savings? only for safety
- Basement Duct Sealing
  - Savings = 1%-3% found in several studies,
    - maybe if basement is hottest room, fix big holes, return dP
- Water Heater Replacements
  - May save 30-50 th/yr but too expensive, tankless EF over-rated
- Small behavior changes with trivial impacts
  - change furnace filters monthly, cook with lids on pots, clean fridge coils, close fridge quickly, close drapes at night