ASSESSING 116 DEEP RETROFITS ACROSS THE U.S.

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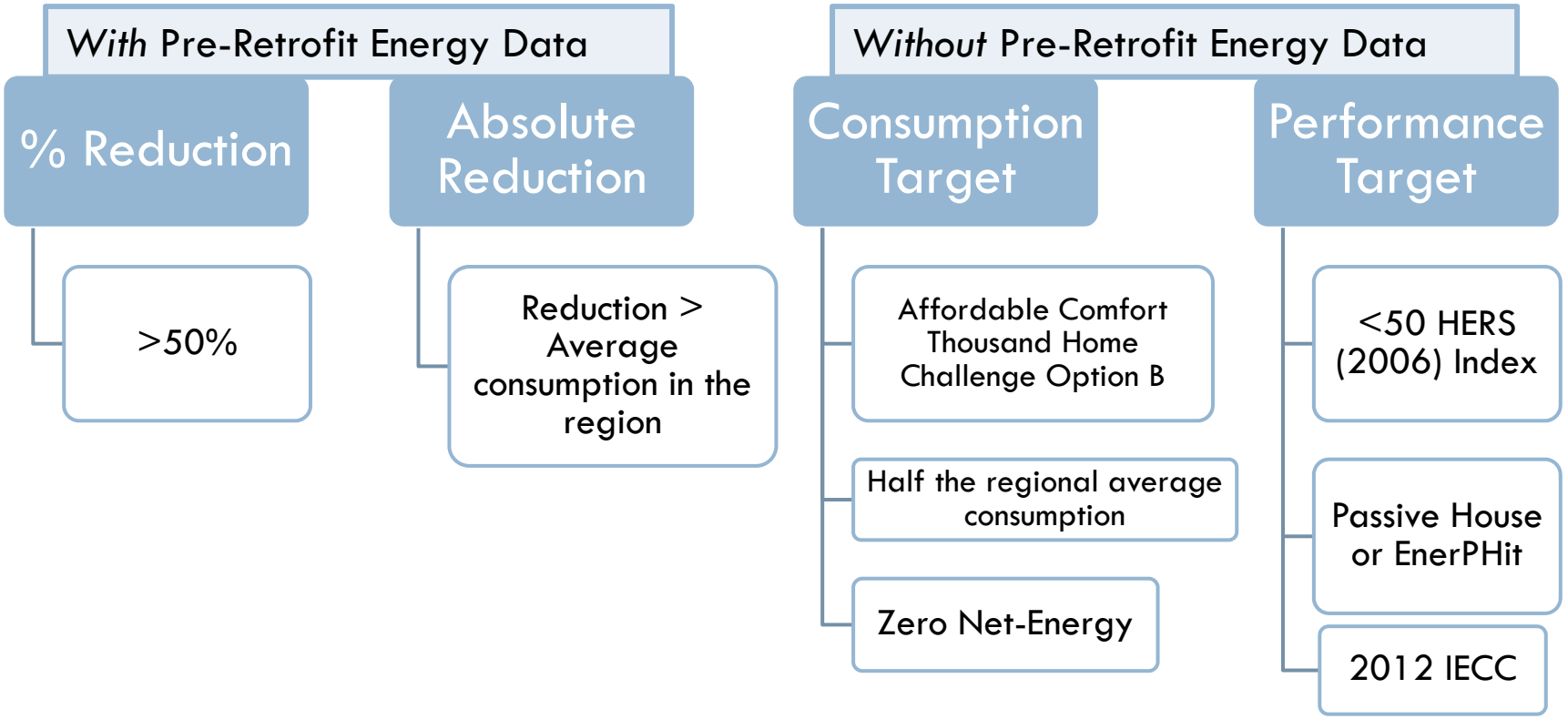
ACI National Home Performance Conference, Detroit, MI, 04/30/2014

Defining a Deep Energy Retrofit—Variable and Flexible

- Comprehensive upgrades to the building enclosure, heating, cooling and hot water equipment.
- Often incorporates appliance and lighting upgrades, plug load reductions, renewable energy and occupant conservation.



Past and Present DER R&D Efforts

- Major Energy Retrofit methods were documented in North American cold climates in the 80's
- ACT^2—demonstrated actual saving >50% in small sample of existing California homes in the 90's
- Simulation efforts have suggested that DERs are feasible and possibly economically justified in existing homes
  - Canada (Henderson & Mattock, 2007)
  - Europe (Becchio et al., 2012)
  - U.S. (Fairey & Parker, 2012; Polly et al., 2011)
- Numerous deep retrofit efforts have been documented in actual homes in the EU
  - IEA Task 37 – 76% tech systems savings in 60 DERs
  - UK SuperHomes - >170 DERs with >60% CO_2 reductions
  - UK Retrofit for the Future - >100 DERs targeting 80% CO_2 reductions
  - EnerPHit – Passive House certification criteria for refurbished buildings

LBNL Review of U.S. DERs

- Reviewed the available literature, collected DER data for meta-analysis
  - Likely to be more DERs that are undocumented
  - Included owner-occupied, affordable housing, community redevelopment (foreclosures), research homes, and green remodels
- Data sources
  - U.S. DOE Building America reports
  - U.S. DOE National Lab reports
  - ACI Thousand Home Challenge
  - Utility retrofit programs
  - USGBC/ASID REGREEN
  - Magazine articles (JLC, Home Energy)
  - Presentations
  - Architects/Builders

What Counted As "Deep"?

- Projects self-identified as DERs
  - Project scopes were aggressive and comprehensive (i.e., targeting all or nearly all building assemblies, services and end-uses)
  - Projects also had to provide at least one of the following—airtightness, energy use or cost data
- Variable performance targets:
  - HERS <70
  - 30-70% energy reductions
  - Meeting Passive House standards
  - Various green certifications and Energy Star
- There was substantial variability in cost data reporting, and we used a mix of whatever was reported in primary sources (Least Reliable)
- Data includes BOTH simulated and actual results

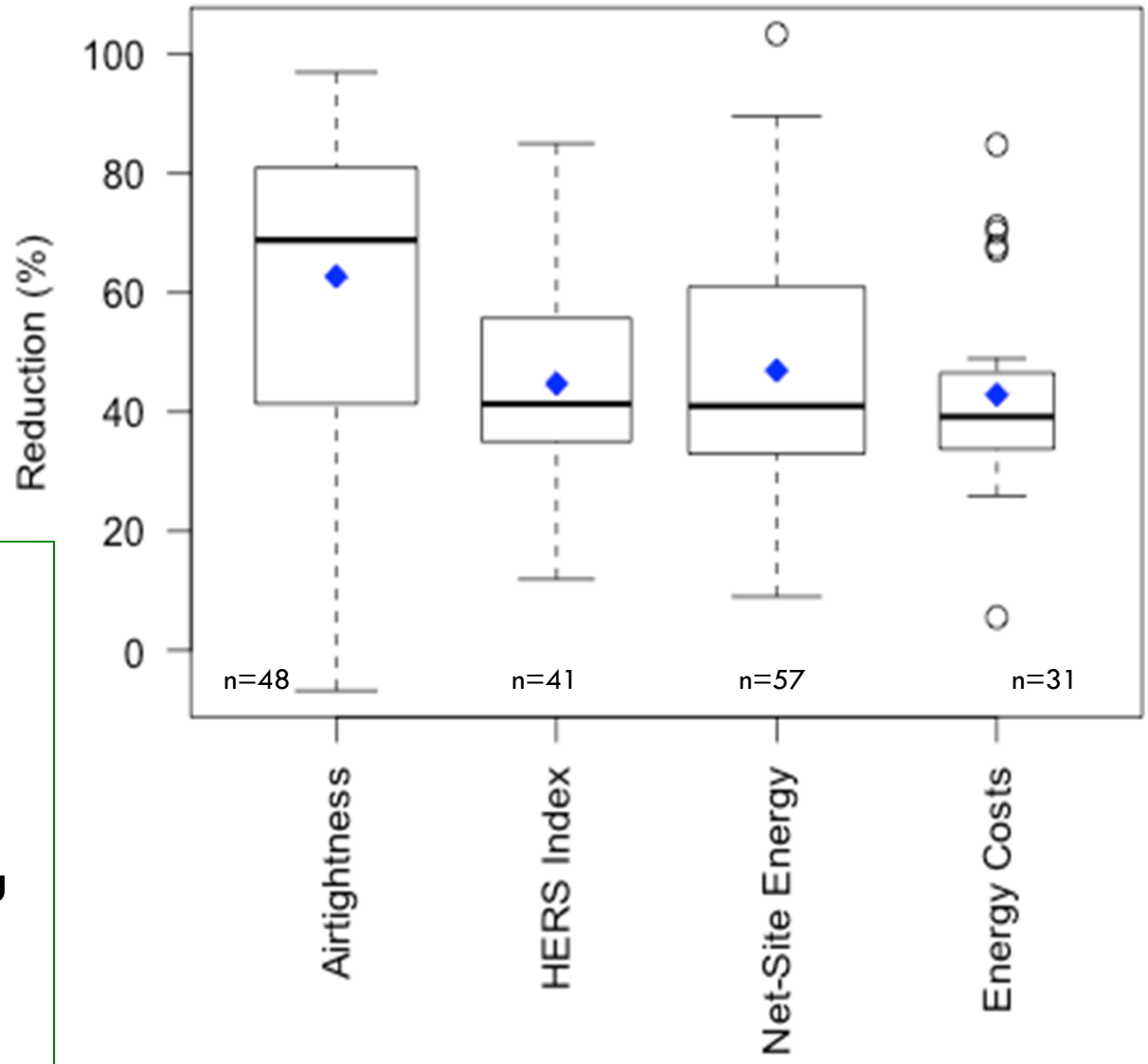
Summary of Reductions Achieved by U.S. DERs

ACH: 16➔5 ACH_{50}

HERS: 151➔68

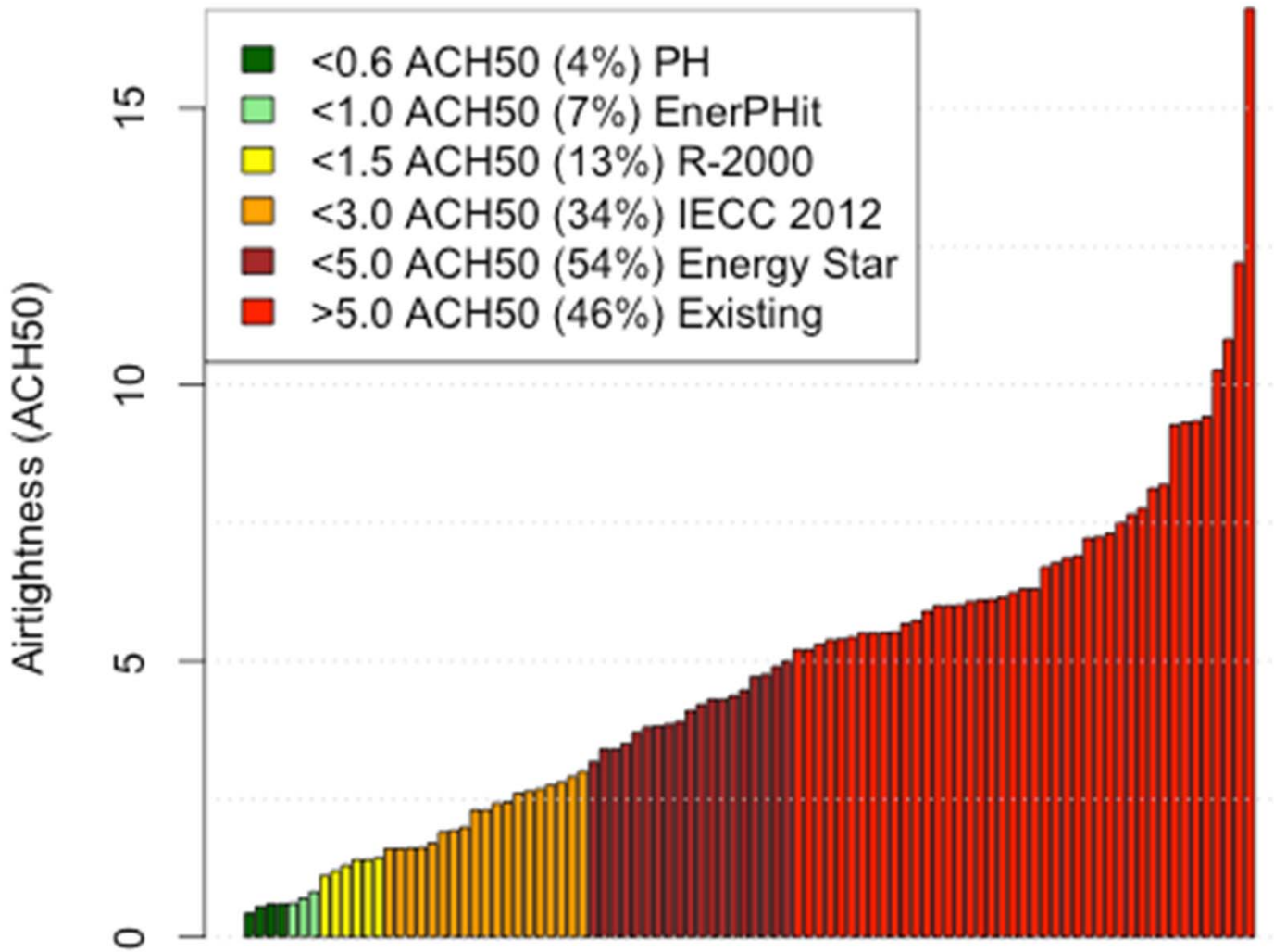
Energy: 127➔48 MMBtu

Costs: $2,738➔$1,588



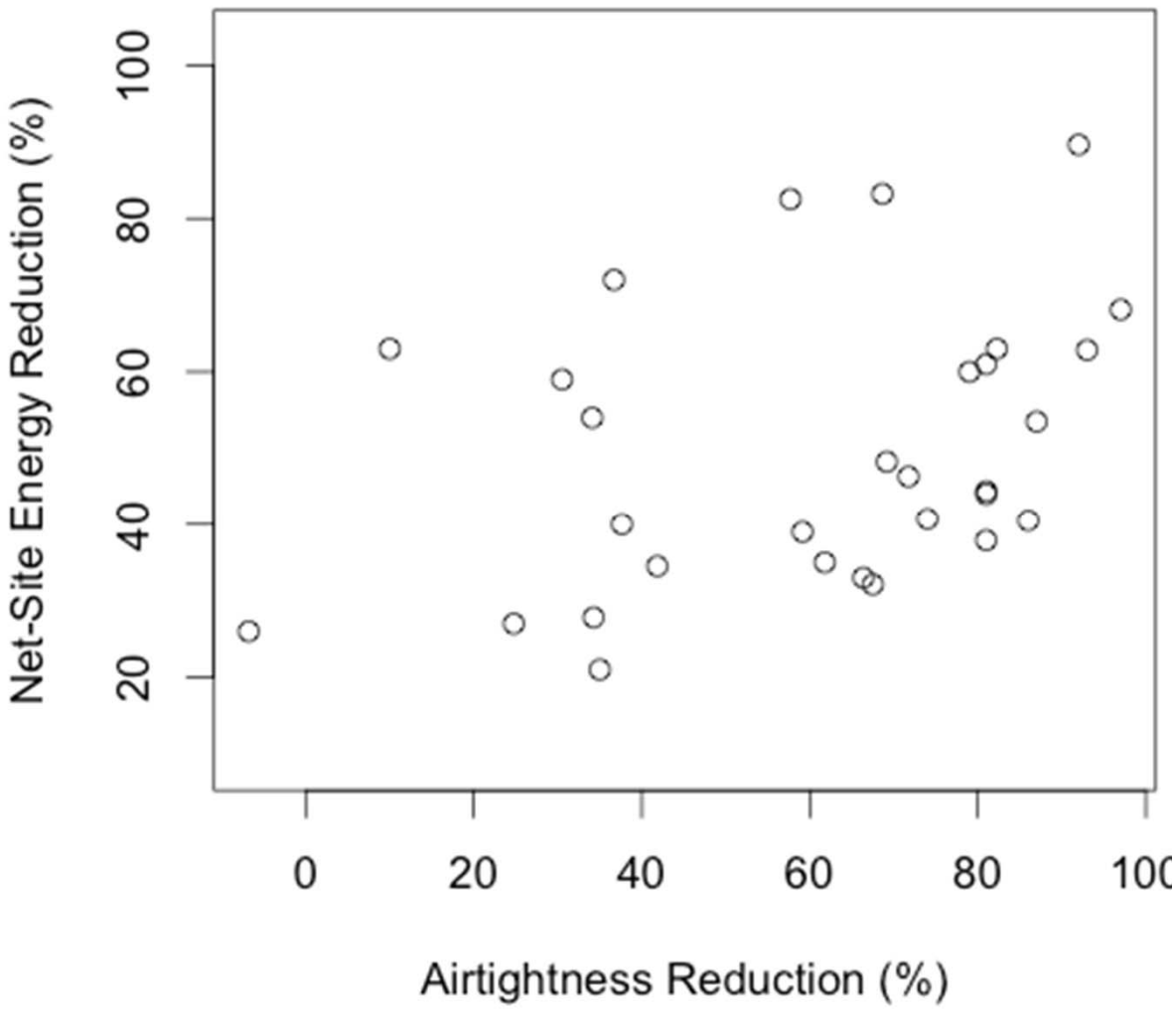
Post-Retrofit Airtightness in U.S. DERs—Comparison to Programs and Codes

- ~70% installed mech. venting
- <50% in non-Cold climates
- ~70% were ERV/HRV

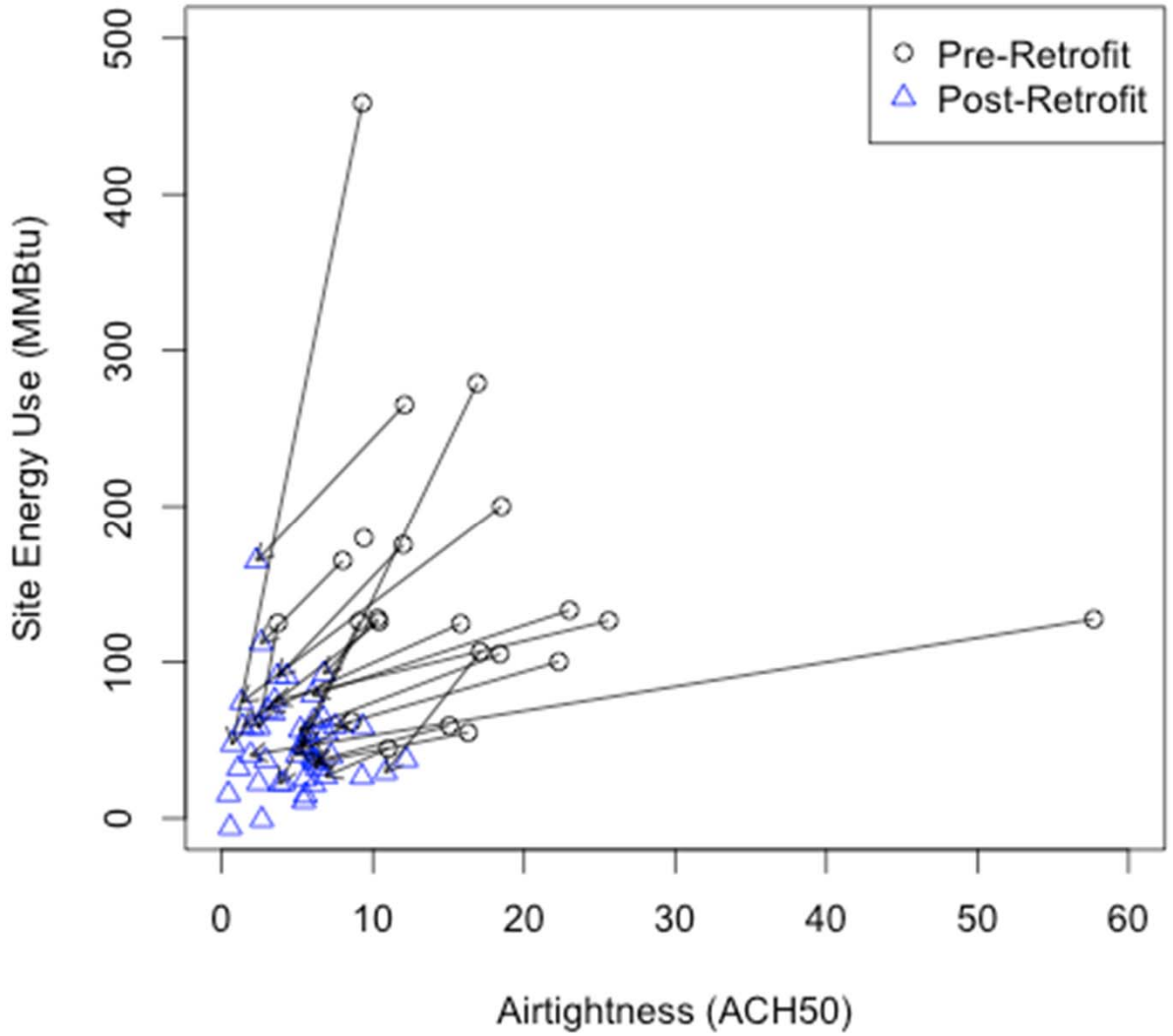


Does Airtightness Predict Energy Savings?

- In comprehensive upgrade projects, you cannot use one element to predict performance of the whole!
- Variability in climate, house size, insulation, HVAC, pre-retrofit usage, and behavior all "interfere"



Does Airtightness Predict Energy Savings?

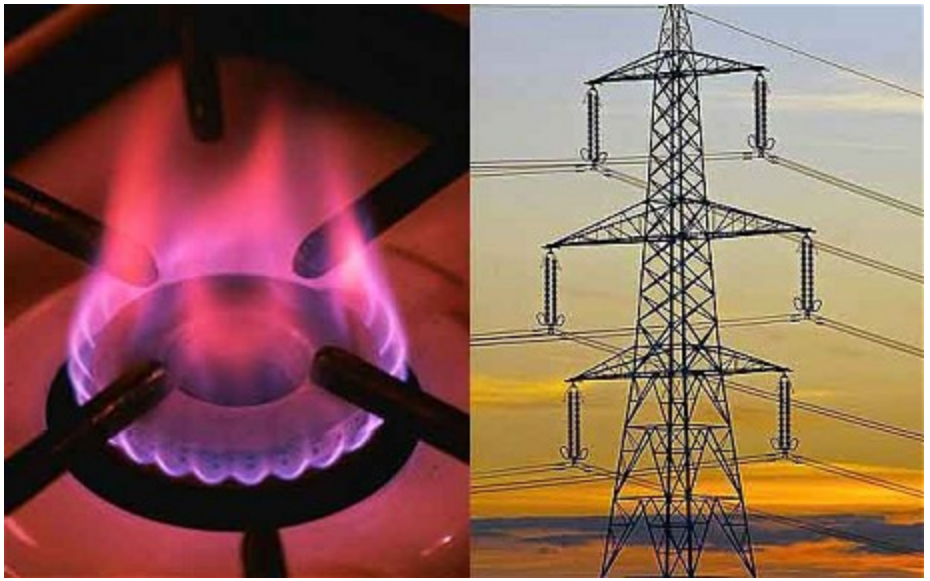


What's Happening Here?

- DERs can be successful across a range of airtightness levels
  - But MORE airtight = MORE savings for any given home
- Air sealing is still generally essential, cost-effective, and smart in nearly all DER projects
- **We recommend** targeting new construction levels
  - Gut rehabs: <3 ACH_{50}
  - Others: <5 ACH_{50}
  - IECC 2012
  - Or 60-70% leakage reductions

Impacts of Changing Fuel and Increasing Misc Electricity in DERs

- 7 DERs in this review increased electricity use as a result of retrofit. Why?
  - Natural gas → Electric
  - Addition of energy using home features
    - Lighting, mechanical ventilation, dehumidification, cooling, A/V.
- Results for these 7 DERs:
  - Net-site = 52%
  - Net-source = 34%



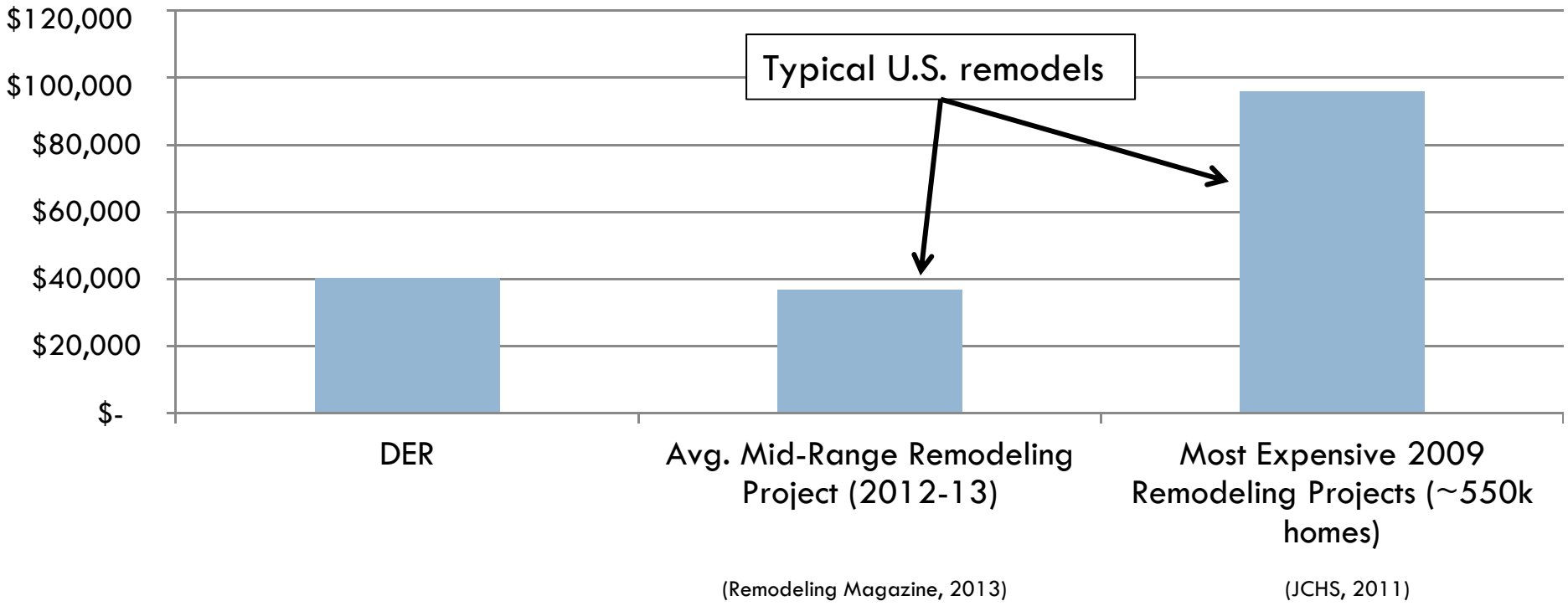
How frequent is fuel-switching in DERs?

When is it problematic and when is it OK?

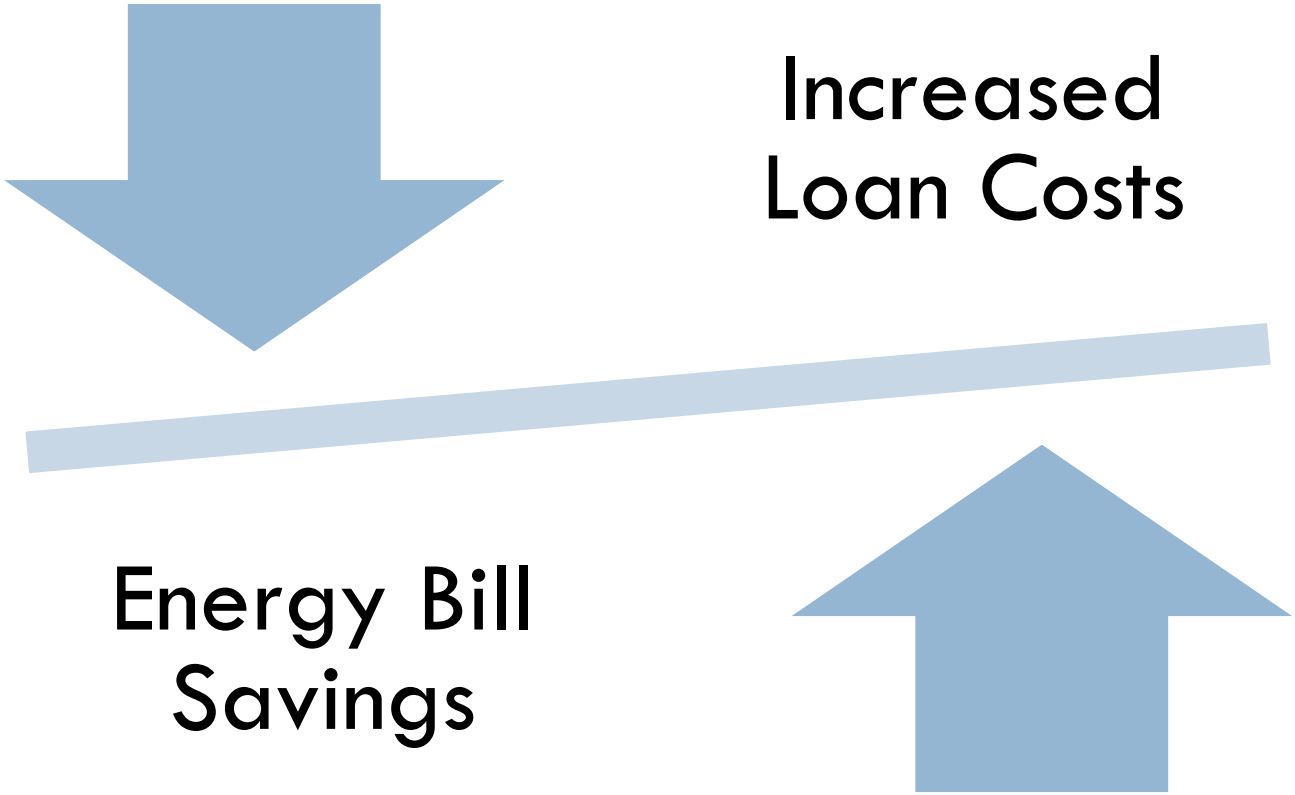
What drives fuel-switching?

How Much Do DERs Cost?

- Reported average project costs:
  - $40,420 ± $30,358 (n=59)
  - $22.11±$17.70 per ft^2 (n=57)

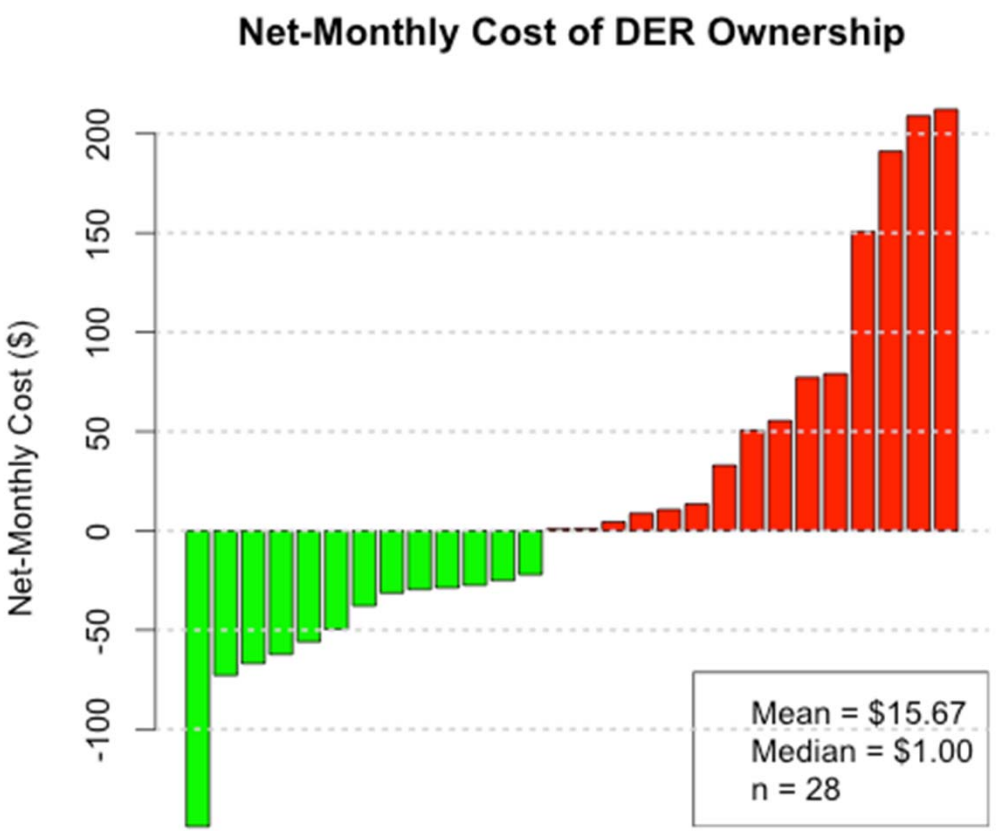


How to Assess Cost-Effectiveness



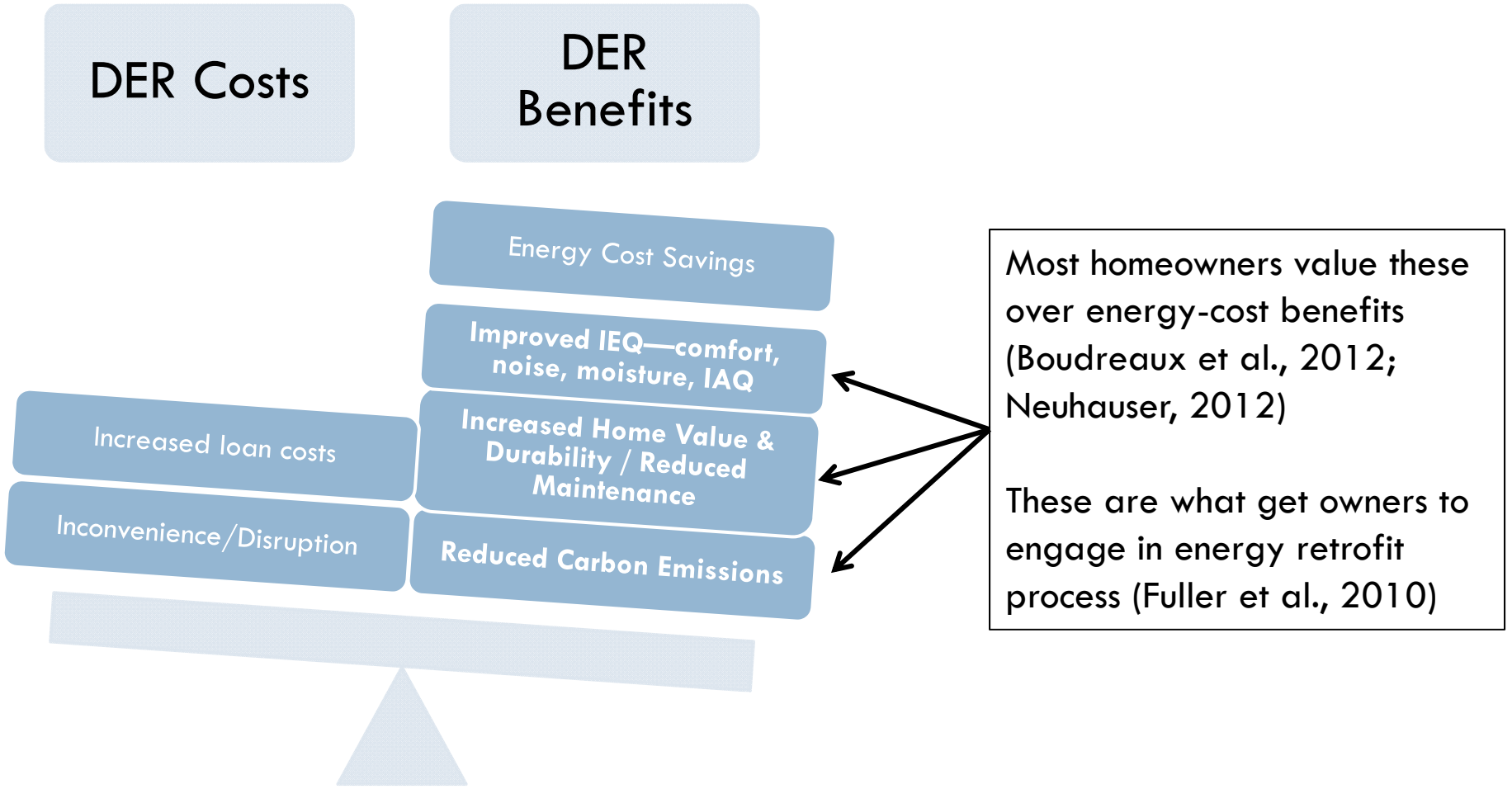
Financed Costs of DERs

- Pre-conditions very poor and entirely un-insulated
- Vast majority of energy use is heating with expensive diesel fuel
- Energy bill reductions larger than avg.



- Very aggressive, super-insulated projects.
- Low pre-retrofit energy costs
- Pre- conditions include some insulation or 2x pane windows
- Big PV array
- Cold climates or newer home
- Increased electricity use
- Addressed only/primarily heating

DER "*Value*" in a Wider Context



Most homeowners value these over energy-cost benefits (Boudreaux et al., 2012; Neuhauser, 2012)

These are what get owners to engage in energy retrofit process (Fuller et al., 2010)

DER Summary

Energy Performance

- 47% Avg. Reduction
  - 16% > 70%
- Reductions ≈ Avg. U.S. Home Usage

Asset Performance

- HERS 68 (predominantly Hot-humid)
- Airtightness better than Energy Star in ~50% of DERs
- 63% avg. reduction
- Mechanical ventilation not always provided

Cost

- Savings: ~$1,300/yr.
- Costs: ~$40k
- Financed DERs can be cost-neutral
- Massive value potential in NEBs

DER Guidance

- **Comprehensive**ly address **all** building systems and end-uses, and plan with **occupant involvement** where feasible
- Use **simple designs and off-the-shelf** equipment, beware highly-engineered, custom systems
  - Lower costs, lower maintenance, more serviceable
- Select **lower-cost options** wherever equivalent/adequate performance is possible
  - GSHP vs. mini-split
  - Spray polyurethane foam vs. dense-pack cellulose
  - Efficient gas heater and dhw vs. solar combi-system boiler
- Use **skilled contractors**/subs whenever available (often impossible)
  - Problems with inexperienced contractors, subs and suppliers repeatedly identified as major barrier in our review
- Target **existing remodeling projects and equipment replacement** with incremental DER measures

DER Guidance Continued

- In airtightened homes, provide adequate **ventilation** using ASHRAE 62.2-2013
- Consider site, **source and carbon** assessments
  - Societal Impacts → use source energy and carbon emissions
  - Occupants → use site energy and energy bill costs
  - **Most important when changing fuel mix and/or adding end-uses**
- Decisions in owner-occupied DERs are rarely just energy/cost based
  - Focus marketing and sales efforts on **non-energy benefits** like comfort, safety, durability, aesthetics, noise, etc.
- Consider **staged retrofit** approaches
  - Integrated with maintenance and equipment replacement
  - Less disruptive than whole house remodel

Thanks!

- Brennan Less
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- Iain Walker
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- Research Report:
  - http://eetd.lbl.gov/publications/a-meta-analysis-of-single-family-deep
- http://homes.lbl.gov/

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