EFFECTS OF OCCUPANT AND DESIGNER BEHAVIORS ON RESIDENTIAL DEEP ENERGY RETROFIT PERFORMANCE

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DEEP ENERGY REDUCTIONS ARE REAL



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How Can Behavior Affect the Success of DER?

Space Conditioning	 Thermostat set-points, use of heating/cooling Level of building envelope intervention
Hot Water	Hot water temperatureReducing hot water use, fixture and occupant
Ventilation	Presence of continuous mechanical ventilationKitchen ventilation
Lights	Lighting design and bulb typeLighting control, automatic or human
Plugs	Limit the number of devices usedTurn off devices when not in use
Appliances	Do you need a dryer?Keeping old, inefficient appliances

Behavior Effects DER Success at Different Phases



- Builder installed devices
- Old appliances
- Controls
- Simple and robust measures
- Adhere to 3rd party program req.'s (LEED, Passive House, etc.)

• Quality construction practices

- points
- # of devices used
- Turn off lights/ plugs/appliances when not used
- Maintenance
- Learning where energy goes

So What Do DER Occupants Look Like? And How Do They Behave?

Lots of variability

- Some engage in active conservation, others do not, others are in between; in other words, they're just like everyone else
- For some, DERs allow them to live life normally (with all the bells and whistles), while reducing their impact
 - Lots of plug-in devices
 - Structured wiring for smart home tech
 - Typical indoor comfort levels
- Others actively work to reduce usage, often pursuing energy use targets (1000 Home Challenge, for example)
 - Actively reduce plug-in devices (no dryer, smart power strips, unplugging our monitoring equipment, etc.)
 - Lower levels of indoor comfort, with possible clothing supplementation (sweater in winter, shorts in summer)
 - Use energy dashboard to manage and understand usage



DER Occupant Density



"Other" Discretionary Energy Use

Comparisons



CA and US Averages, (RECS, 2005)

"Other" Energy Use by # of Occupants



Average Electrical Baseload Comparison



Monthly Average Indoor Temperatures, All Projects





P6 North Monthly Living Room Temperature Profiles, Winter and Summer

Hour of the Day

Using Passive House to Limit Occupant Influences





Using Conservation to Overcome Old Appliances and Mediocre Envelope





No Need for a Heating System in Passive House? Think Again.





Old Refrigerator + High Efficiency Solar Combisystem = DER???







Approaches to DER— Balancing Behavior and Technology



Deep Energy Reduction

Deep Energy Reduction

- Both approaches were successful in this research
- Finding the appropriate balance will make:
 - DER more successful at achieving targeted energy reductions/performance
 - DER less expensive and disruptive



- Achievement of aggressive energy performance goals has been inconsistent (ZNE, DER, etc.)
- Consistent achievement is more likely if occupant behavior is incorporated into the design process

Image source: https://encrypted-tbn3.gstatic.com/images? q=tbn:ANd9GcSTQvd4773CumjXQaF2X8wEyMi_Y1mpVh0uAcSXk7tjJlaApwLp

DER Paths for Different Occupants



- Code-compliant building envelope
- Make active energy management easy —monitoring, switched outlets, etc.

Unengaged Occupants

- Enhanced building envelope
- Install automatic controls to manage energy—timers, motion sensors, smart home, etc.

Conclusions/Suggestions

Leveraging the behavioral patterns of DER occupants can be key to success

Increased energy reductions

Reduced costs

- □ When planning a DER, identify:
 - Willingness to conserve
 - Level of occupant engagement
 - Comfort requirements
 - Existing patterns of usage, conservation, etc.
- Utilize this behavioral knowledge in design/planning

Thanks!!

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