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Hybrid Session , "C5: Advanced Modeling: Calibration,"

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Smart Thermostat Data-Based Residential Buildings Remote Energy Assessments: You Are Probably Doing It Wrong!

Learning Objectives

Objective 1 – Identify the main challenges and limitations of state-of-the-art home energy audit techniques.

Objective 2 – Describe a new method for remote energy audit, an alternative to existing methods.

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- Rick Wester – National Grid

Context: Homes energy efficiency improvements importance

$5bn

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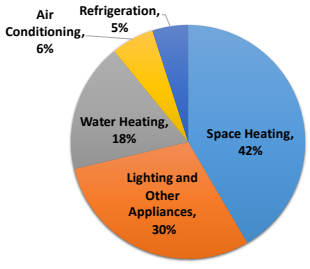
Potential (energy) savings of up to $5 bn/yr

Space heating/cooling represents ~48% of homes energy use



Why and how energy is wasted in homes?

~20-25% of U.S. homes have poor or no insulation

Why and how energy is wasted in homes?

~28% of heat loss is due to air leakage

How to identify buildings that need retrofits?

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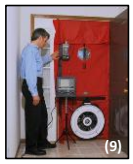
Current practice: onsite energy audits



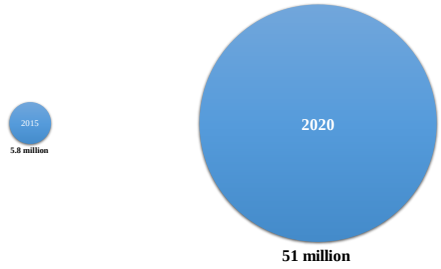
- Professional energy audits take time (30 min to +4h)
- Expensive ($400 to +$1000)
- Variable accuracy

On site audits is not scalable ➔ we need a new solution!

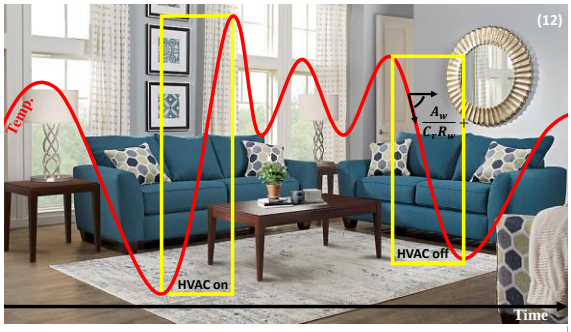
CT and smart meters are creating an opportunity

Communicating thermostats (CTs) and smart meters data can be used to do remote energy auditing

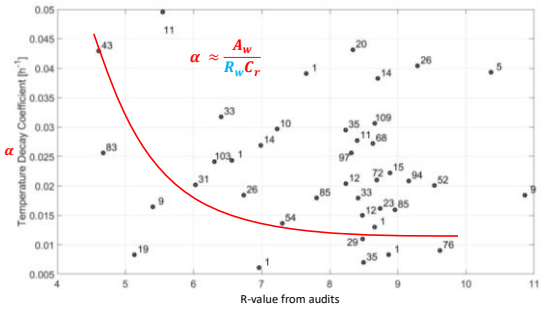
Increasing # of homes equipped with CTs (~51 million in 2020)



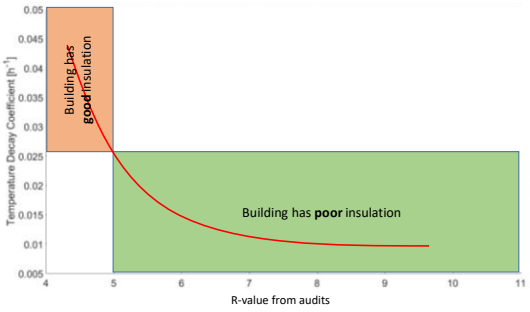
Home thermal signature



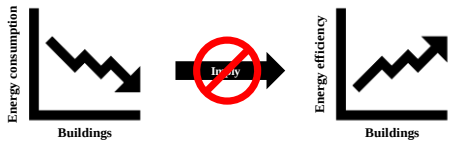
Remote energy audit: Temperature decay approach



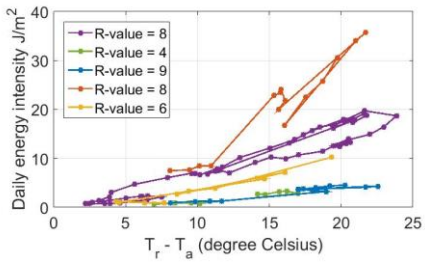
Remote energy audit: Temperature decay approach



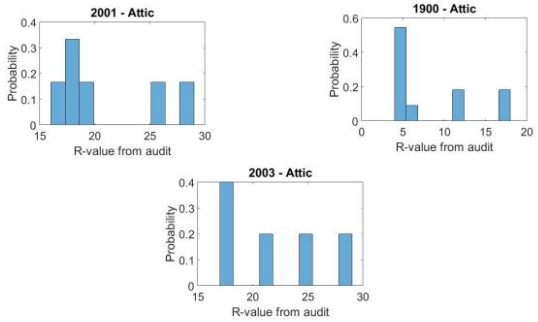
Remote energy audit: Energy intensity approach



Remote energy audit: Energy intensity approach



Remote energy audit: maybe R-value = f(year, location)?



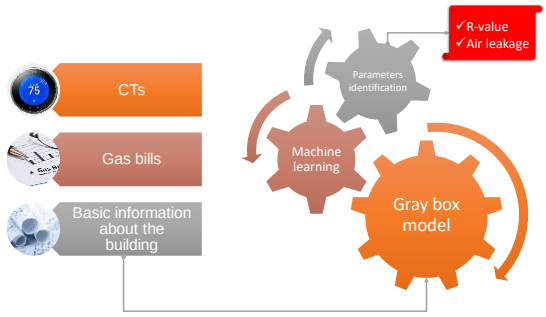
Remotely evaluate and identify residential space heating retrofit opportunities customized to individual homes:

- ✓ Insulation level
- ✓ Air leakage level

Customer and utility benefits

Increase market uptake of retrofit measures (currently <1% in Mass)	Decrease the cost of energy efficiency programs
Reduce retrofit performance risks using remote EM&V	Increase customer engagement

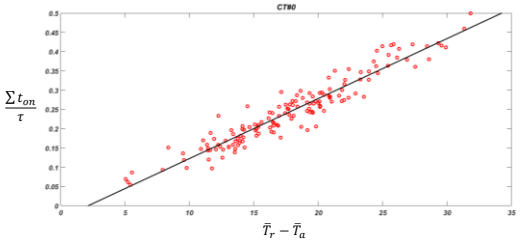
Energy audit embedded in the developed algorithm



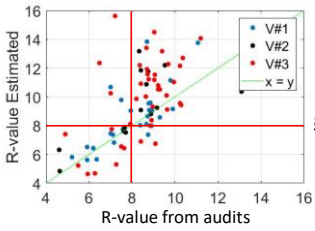
Typical CT data scatter

$$\frac{\sum t_{on}}{\tau} = \left[\frac{A_w}{R_w Q_{hvac}} + \sqrt{\left(\frac{\rho c_p}{Q_{hvac}}\right)^2 C_v \bar{U}^{2.6} + \left(\frac{\rho c_p}{Q_{hvac}}\right)^2 C_t |\bar{T}_r - \bar{T}_a|^{1.3}}\right](\bar{T}_r - \bar{T}_a) - \frac{q}{Q_{hvac}}$$

Air infiltration model

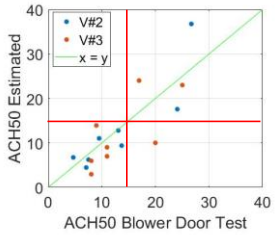


Results: R-value estimation



88% classification accuracy

Results: air leakage estimation



93% classification accuracy

QUESTIONS?

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Conclusions

- **Onsite homes energy audits are not scalable:**
  - Expensive and time consuming
  - Variable accuracy
- **Some remote energy audit methods have limited validity due to:**
  - Unable to isolate air leakage from thermal loss by conduction
  - Variable internal heat capacity/thermal mass and size of homes
  - Statistical models have limited generalization power
  - Some important disturbances are neglected
- **For homes with 1CT, using the proposed approach we can:**
  - Estimate Air leakage
  - Classify whole-home thermal resistance
  - Separate insulation from air sealing opportunities
- **In progress:**
  - Extend algorithms to homes with multiple thermostats
  - Finalize recommendations for scale-up: CT Data Specification

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