

# Energy Insecurity in Redlined America

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## Energy Insecurity

The disproportionate share of household income allocated to energy expenses with those that exceed a 10% threshold categorized as experiencing "energy insecurity." (Hernández 2015)

- Drehabl and Ross (2016) find 75th percentile energy burdens above 26%.
- Lyubich (2020) finds minority households spend more on energy
- Doremus et al (2021) finds low-income households use more energy during weather extremes

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## Energy Inequity

- Reames (2016): Minority-dominated census block-groups tend to have lower (worse) energy efficiency and spend a greater total amount **for the same level of energy services relative to non-minority households.**
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**Energy Inequity:** "The disproportionate incidence of energy insecurity in heavily-minority areas relative to non-minority areas of similar income."

## Why?

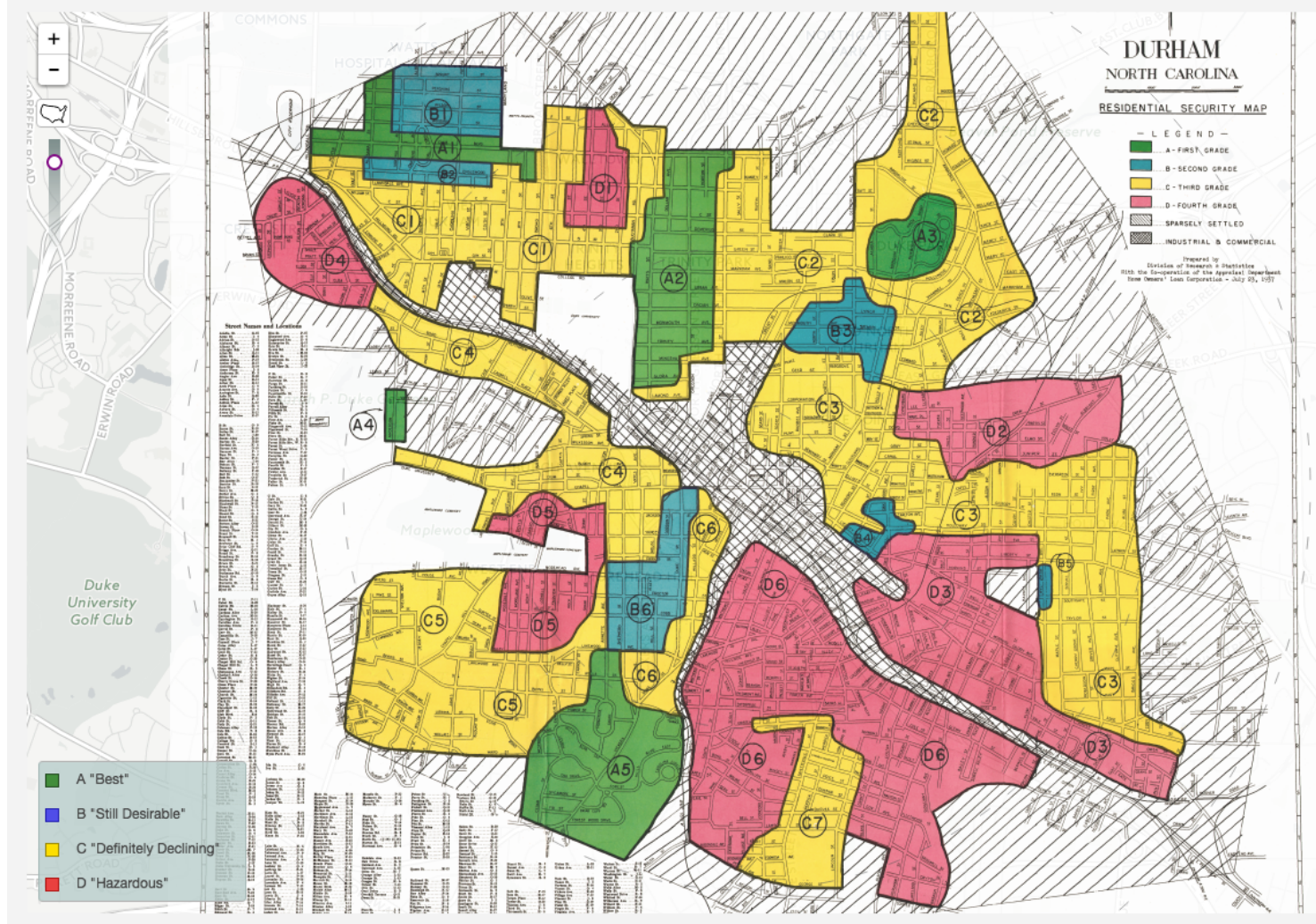
- Preferences & Sorting?
  - Lower-efficiency homes are less expensive, income constraints → "coming to the nuisance" (Banzhaf, 2011; Depro et al, 2015)
  - But conditional on income, do minority households prefer lower efficiency?
  - Lower utility of heating? Lower utility of non-energy consumption?

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- Current housing discrimination or heterogeneous information?
  - Christensen et al (2020): Rental agents steer minority households away from low-toxic exposure properties
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- State dependence / hysteresis
  - Historic forms of discrimination
  - Frictions in moving costs



Durham, NC Redlining Map (source: URichmond Mapping Inequality)



## Homeowners Loan Corporation (HOLC)

- New Deal agency tasked with assessing mortgage risk for federal refinancing efforts
- Neighborhoods risk-graded by local agents 1933-1939
- Largely considered "subversive minorities" to be harbinger of decline and risk.
- Widespread discrimination in housing via discriminatory lending

NS FORM-B  
2-3-37

AREA DESCRIPTION  
(For Instructions see Reverse Side)

1. NAME OF CITY Durham, N. C. SECURITY GRADE C AREA NO. 5

2. DESCRIPTION OF TERRAIN Rolling

3. FAVORABLE INFLUENCES: All city conveniences, fair transportation

4. DETRIMENTAL INFLUENCES: Cemetery on north, and old amusement park

5. INHABITANTS: Mechanics, tobacco workers,  
a. Type Clerks; b. Estimated annual family income \$ 600 - \$2500  
c. Foreign-born None %; d. Negro Yes %; 1 %  
(Nationality) (Yes or No)  
e. Infiltration of None %; f. Relief families Few %  
g. Population is increasing Slowly ; decreasing ; static

6. BUILDINGS: Small singles and  
a. Type or types duplexes ; b. Type of construction Frame ;  
c. Average age 12 - 15 years ; d. Repair Fair

7. HISTORY: SALE VALUES PREDOMINANT RENTAL VALUES  
YEAR RANGE INATING % YEAR RANGE INATING %  
1929 level \$1800 - \$6000 \$2500 100% \$20 - \$40 \$25 100%  
1933 low \$1200 - \$4500 \$1800 70% \$15 - \$35 \$20 80%  
current \$1800 - \$5000 \$2250 85% \$15 - \$40 \$25 100%  
Peak sale values occurred in 1929 and were 100 % of the 1929 level.  
Peak rental values occurred in 1929 and were 100 % of the 1929 level.

8. OCCUPANCY: a. Land 20 %; b. Dwelling units 98 %; c. Home owners 50 %

9. SALES DEMAND: a. Fair ; b. \$2250 singles ; c. Activity is Fair

10. RENTAL DEMAND: a. Good ; b. \$25 singles ; c. Activity is Good

11. NEW CONSTRUCTION: a. Types Small singles ; b. Amount last year Mediocre

12. AVAILABILITY OF MORTGAGE FUNDS: a. Home purchase Limited ; b. Home building Limited

13. TREND OF DESIRABILITY NEXT 10-15 YEARS Static

14. CLARIFYING REMARKS: Best portion along Chapel Hill Road and part of James Street

Example survey. (URichmond Mapping Inequality)

$\theta_0$ : Energy Inequity is in part the result of a *hysteresis* effect rooted in historic housing discrimination.

Redlining was a "critical juncture" that separated otherwise similar housing stock.

- Test by examining modern differences in home energy services quality between redlined and observably similar non-redlined households, measured as
  - (1) *presence of sufficient heating technology* and
  - (2) *energy consumption responses to cold weather shocks*
  - Controlling for historic and current small neighborhood characteristics

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## Not addressed here

- Lending discrimination debatably ended with CRA in 1977. Households able to migrate, re-sort. Why does Energy Inequity persist?
- Test for "stickiness" of neighborhood.
  - High non-market moving costs.
  - Neighborhood support, family proximity, etc.

Historic data → many assumptions

## Prior literature

- Hoffman et al (2020) urban heat islands and redlined areas
- Nardone et al (2019) asthma and redlined areas
- Aaronson et al (2020) examined credit availability in redlined areas over 1930-1980 with RD-based analysis

## Enlightening and incredibly inconvenient:

Fishback, La Voice, Shertzer, and Walsh (2020) on **endogeneity of redlining designation**.

- Used linked 1930 census address data and HOLC maps to show that redlined areas captured pre-existing economic and racial discontinuities in space.
- Border discontinuities not smooth in unobserveds. Even large moves in boundaries would still capture pre-existing segregations.
- Hillier (2003) no widespread proof that HOLC maps were distributed and used.

## Empirical strategy

Acknowledging Fishback et al (2020), I control for selection on observables:

- Rent in 193X
- Income in 193X
- Presence of minorities in 193X
- Repair quality of housing in 193X

### Assume:

- Conditional on observables that determined selection, Grade D (red) is as good as randomly assigned
- Unobserved neighborhood characteristics in 1930's not captured by observables are no longer relevant today.

## Identification of effect of redlining uses observably similar HOLC neighborhoods

- Many Grade C (yellow) areas had larger Black populations, lower rents, worse home repair than nearby Grade D (red).
- Multiple surveyors

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- Many Grade C (yellow) areas had larger Black populations, lower rents, worse home repair than nearby Grade D (red).
- Multiple surveyors
- Drawback: leaning on linear controls.
  - Solution: very flexible with linear controls.

## Measuring along two outcomes:

### (1) Presence of sufficient heating technology in 2018

- Ask "are there currently differences in heating sources between redlined and near-redlined homes, controlling for selection on observables?"
- Substandard heating technology = Coal or "None"
- Requires spatially explicit heating fuel use

### (2) Energy consumption responses to cold weather shocks

- Ask "are there currently differences in energy consumption responses to weather shocks between redlined and near-redlined homes, controlling for selection on observables?"
- Data on monthly consumption and heating degree days for households in Grade D / Grade C areas (12-19 months)
- Requires spatially explicit household electricity consumption with income

## HOLC from URichmond "Mapping Inequality"

- 196 cities, 8,877 neighborhoods
- Survey data processed
  - Grade A-B-C-D
  - Repair class
  - Median Income 1936
  - Mean rent 1936
  - Presence of Blacks 1936

## 2018 ACS at block-group

- 44,357 BGs intersect HOLC
  - Heating fuel
  - Coal + "None" → substandard
  - Racial distribution
  - Median income 2018



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Overlay BG with HOLC, keeping those BG that have >80% within one grade

- Take areal average when BG covers multiple HOLC neighborhoods of same grade
- 6,715 have most HOLC information

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All block-groups in Berkeley, CA



## Measuring Hh response to temperature shocks

### California RASS (Residential Appliance Saturation Survey)

- Confidential dataset with 24,216 homes surveyed in CA in 2009
  - Monthly consumption (from utility) for electricity, gas (if used)
  - Monthly HDD and CDD
  - Primary heating fuel
  - Income
  - Nighttime thermostat setpoint
  - Daytime thermostat setpoint
  - **Zip code**
- 138 households in 37 zip codes with >80% coverage for electric
- 1,018 households in 83 zip codes with >80% coverage for gas

## Flexible fixed effect specification

$$\textit{PercentSubstandard}_b = \beta_0 + \sum_{g \in \{A, B, \}} \beta_g + \beta \mathbf{x}_b + \gamma_{c(b)} \mathbf{w}_b + \Gamma_{c(b)} + \epsilon_b$$

- *PercentSubstandard* is share of 2018 homes with coal or no heating fuel in block-group  $b$
- $\beta_g$  is coefficient of interest
- $\mathbf{x}_b$  is repair class, 2018 demographics
- $\Gamma_{c(b)}$  are county FEs for county  $c$
- $\gamma_{c(b)}$  are county-specific slope shifters
- $\mathbf{w}_b$ 
  - Median income in 1936, 2018
  - Mean rent 1935
  - Presence of Blacks in 1936

Table 1: Share of Households with Substandard Fuel (Coal and None) by HOLC Grade

	Dependent Variable: Share of Households in Block Group with Substandard Heating			
	Model 1	Model 2	Model 3	Model 4
Grade D (Red)	0.00335* (0.00160)	0.00279+ (0.00155)	0.00285* (0.00143)	0.00416** (0.00135)
Grade B (Blue)	-0.00071 (0.00158)	-0.00050 (0.00161)	-0.00078 (0.00126)	0.00006 (0.00140)
Grade A (Green)	0.00005 (0.00280)	0.00045 (0.00289)	0.00042 (0.00239)	0.00180 (0.00322)
Predom. Black 2018			-0.00331** (0.00103)	-0.00223 (0.00144)
Predom. Asian 2018			-0.00408+ (0.00244)	-0.00172 (0.00185)
Predom. other race 2018			-0.00059 (0.00396)	0.00211 (0.00454)
Num.Obs.	6715	6715	3998	3998
R2 Adj.	0.126	0.121	0.070	0.070
FE: STCO	X	X	X	X
Control for home repair status 1935	X	X	X	X
County-specific slope on Med. Income 2018, 1936	X	X	X	X
County-specific slope on Mean Rent 1935	X	X	X	X
County-specific binary on Presence of Blacks 1935		X	X	X
Intx Predom. race 2018 and HOLC Grade				X

+  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Robust SE clustered by FIPS county

Omitted Grade: C (Yellow)

Omitted Race: White

## Response to temperature shocks

Home may have insufficient energy service quality if energy consumption responses to weather shocks are very large.

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Home may have insufficient energy service quality if energy consumption responses to weather shocks are very large.

- Consumption response is endogenous
- Both will have low consumption response to weather shocks:
  - Homes with efficient heating
  - Inefficient homes who meet budget constraints with conservative thermostat settings

$$\begin{aligned}
 consumption_{ht} = & \beta_0 + \beta_1 \quad_{ht} + \sum_{g \in \{A, B, \}} \beta_g \cdot \quad_{ht} \cdot 1(g = g(h)) \\
 & + \sum_{l=1}^3 \sum_{s=1}^5 \beta_{ls} \quad_{ht} \cdot 1(IG \ TSET_h = s) \cdot 1(ClimateZone_h = l) + \\
 & + \beta_{inc} \cdot \quad_{ht} \cdot avgincome_h + \Gamma_h + \varepsilon_{ht}
 \end{aligned}$$

- $consumption_{ht}$  is energy (kWh, therms) consumption for household  $h$  month  $t$
- $g(h)$  is HOLC Grade  $g$  for  $h$
- $\quad_{ht}$  is the heating-degree day for  $h$  in month  $t$
- $IG \ TSET_h$  is the thermostat setting for  $h$
- $ClimateZone_h$  is the climate type for  $h$
- $income_h$  is reported income for  $h$
- $\Gamma_h$  is household  $h$  fixed effect

Table 1: Regression of electricity consumption on heating degree days, interacted with HOLC grade and income, conditional on thermostat setpoint

	Dependent Variable: Energy consumption (kWh)		
	Model 1	Model 2	Model 3
hdd	3.398*** (0.806)	2.598*** (0.184)	
hdd x Grade D (Red)	3.737*** (0.573)	2.809*** (0.727)	3.057*** (0.673)
hdd x Avg rent 37-39	-0.050** (0.018)		-0.011 (0.013)
Num.Obs.	593	1150	593
R2 Adj.	0.804	0.826	0.802
FE: CZT24			X
FE: IDENT	X	X	X
Climate zone FE		X	X
Avg Inc x hdd	X	X	X
hdd x Thermostat setting		X	X
Thermostat setting x Climate Zone x hdd		X	X
Controls for 1937 incl. rent, presence of Blacks	X		X

+  $p < 0.1$ , \*  $p < 0.05$ , \*\*  $p < 0.01$ , \*\*\*  $p < 0.001$

Using only households with elec. as primary heating fuel

Omitted grade is "C"



Table 1: Regression of natural gas consumption on heating degree days, interacted with HOLC grade and income, conditional on thermostat setpoint

	Dependent Variable: Energy consumption (therms)		
	Model 1	Model 2	Model 3
hdd	0.311*** (0.089)	0.280* (0.111)	
hdd x Grade D (Red)	0.121 (0.244)	0.112 (0.245)	0.144 (0.247)
hdd x Avg rent 37-39	-0.001 (0.001)	-0.001 (0.002)	0.001 (0.001)
Num.Obs.	3623	3623	3623
R2 Adj.	0.564	0.563	0.556
FE: CZT24			X
FE: IDENT	X	X	X
Hdd x avg inc	X	X	X
hdd x thermostat setting		X	X
Hdd x thermostat setting x Climate Zone			X
Hdd x controls for 1937 incl. rent, presence of Blacks	X		X

+ p < 0.1, \* p < 0.05, \*\* p < 0.01, \*\*\* p < 0.001

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## Evidence of lingering differences in heating technology in/out of redlined areas

- Remains after controlling for observable differences in 193X
- Useful for targeting of energy efficiency programs

## Evidence of larger consumption responses to cold weather shocks in redlined areas

- Conditional on 193X observables
- Conditional on thermostat setpoints

## Further work

- Understanding selection into Grade D (red)
- "Stickiness" of redlined areas

# Thanks!

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