Exploratory Study on Residential Energy Use

Nanako Tenjin

University of California, Davis

Research Interest

- Household energy use behavior.
  - What factors impact household energy use? How do these factors interact?
    - Indirect vs direct effect
  - Do neighborhood characteristics affect the amount of energy used? If so, how does it affect?
    - Does environmentally friendly designed housing help household reduce energy use in short run and long run?

Research Questions

1. How do household demographics, appliance characteristics, and appliance use, impact electricity use? Are the impacts different in different neighborhoods?

2. If the neighborhood makes difference, does a household reduce energy use by the amount they saved from the neighborhood design, or will the budget be *re-spent* on other energy intensive goods and services?

Exploring Factors of Energy Use

- Structural equation model used to test for direct and indirect effects of socio-demographics

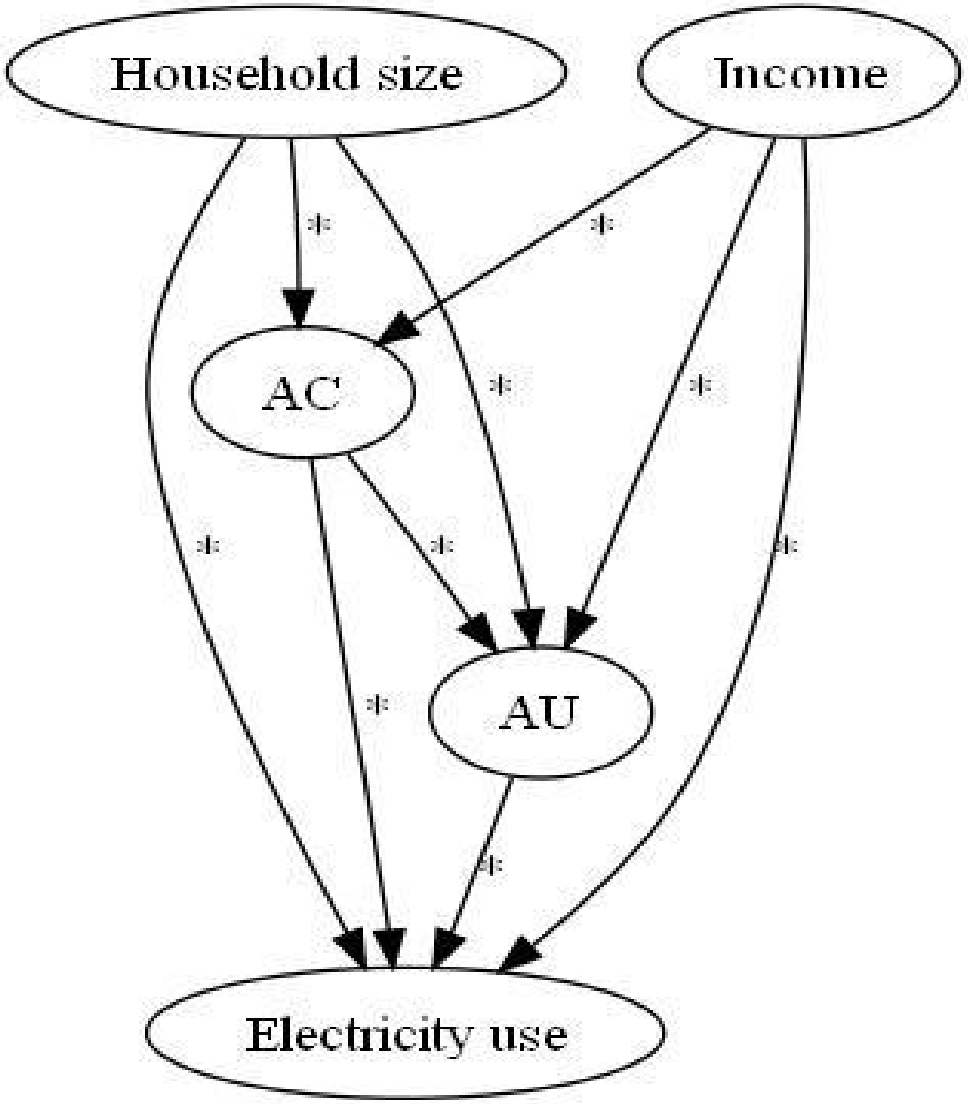
- Variables and factors of interest
  - Electricity use
  - Household appliance characteristics
    - E.g. number owned, age, etc.
  - Appliance usage
  - Socio-demographics of the household
  - Type of neighborhood

Data

- Davis residential energy survey 2007.
- Collected basic dwelling characteristics, types of appliances owned, the ways appliances were used, and socio demographics of the household.
- Overall response rate 37.7%
- Electricity consumption provided by PG&E.
- 379 final sample size after data cleaning.

- Neighborhood comparison
  - Village Homes
    - Built in 1970s. Ecologically designed community and dwellings.
  - Mace Ranch
    - Built in 1980s. Relatively larger houses with newer appliances.

Model



Results

	Variables	Constraint	Standardized â	
			MR	VH
AC	HHS	•	0.152*	0.145**
	Income	•	0.367**	0.421**
AU	HHS	•	0.303**	0.308**
	Income	•	X	X
	AC		X	X
Electricity Use (kWH)	HHS	•	X	X
	Income	•	0.150**	0.196**
	AC	•	0.320**	0.364**
	AU		0.201**	0.272*
Income	HHS	•	(0)	(0)
Residual Variances	AC		0.842	0.801
	AU		0.886	0.896
	kWH		0.751	0.640
Level of significance, 0.01**, 0.05*, 0.10^.				

Summary

- Income and household size both affect the type of appliances owned which affects total electricity used.
- Type of appliances owned does not affect the appliance usage.
- How appliances are used affect energy use, and the impact is different in two neighborhoods. – Captures energy efficient houses, etc.

Research Questions

1. How do household demographics, appliance characteristics, and appliance use, impact electricity use? Are the impacts different for two types of neighborhood?

2. If the neighborhood makes difference, does a household reduce energy use by the amount they saved from the neighborhood design, or will the budget be *re-spent* on other energy intensive goods and services? E.g. transportation energy use?

Measuring *Re-spending*

- Income elasticity
  - Direct estimation using Davis residential survey 2007.
    - Gallons of gasoline consumed in personal vehicle
    - Electricity use

$$E = \left(\frac{\eta_{Transp}}{\eta_{elec}}\right) = \left(\frac{I}{Q_{transp}}\right)\left(\frac{\Delta Q_{transp}}{\Delta I}\right) / \left(\frac{I}{Q_{elec}}\right)\left(\frac{\Delta Q_{elec}}{\Delta I}\right) = \left(\frac{Q_{elec}}{Q_{transp}}\right)\left(\frac{\Delta Q_{transp}}{\Delta Q_{elec}}\right)$$

- Compare with total expenditure trend using U.S. average household obtained from Bureau of Labor Statistics, 1993-2007.
  - Linear approximation of almost ideal demand system (LA/AIDS)

Results

- Direct income elasticity from Davis household.

$$E = \left(\frac{\eta_{Transp}}{\eta_{elec}}\right) = 0.32$$

- One percentage income increase from electricity saving will result in 0.32 percentage expenditure increase in gasoline purchase.
- In case of Village Homes, rebound was 20% in terms of CO2 emission .

Summary

- There is an efficiency gain from neighborhood design in short term.

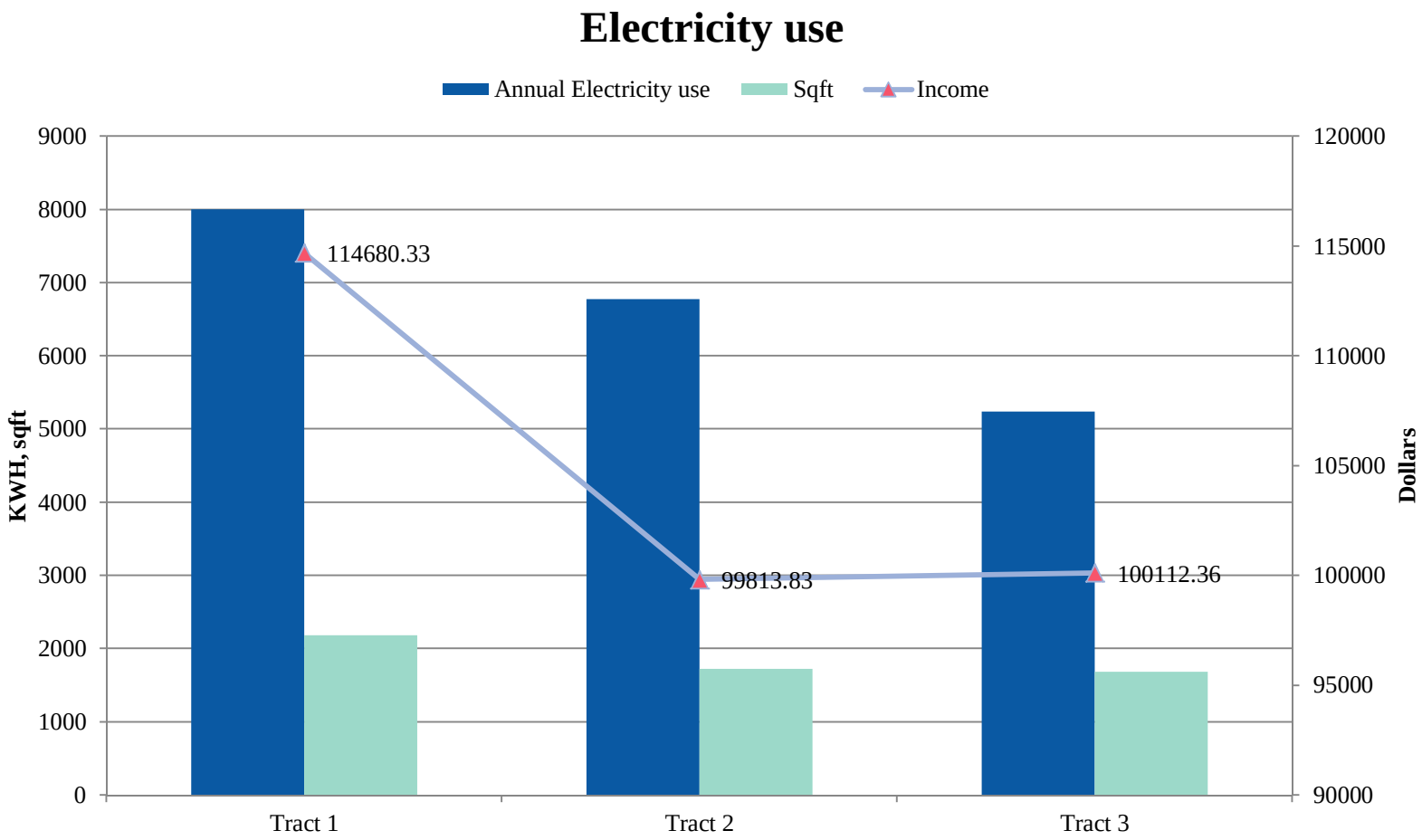
- From BLS data, U.S. average household transportation related expenditure is 1.2 with respect to housing related expenditure. - There is a possibility of rebound in expenditure.

Future Direction

- Energy use SEM: Improve estimation by closely looking at the variables.
- Responding trend: What happens when air travel is included in the transportation expenditure?
- Other factors affecting household choices..
  - Cohesiveness of the community – measuring the closeness among residents

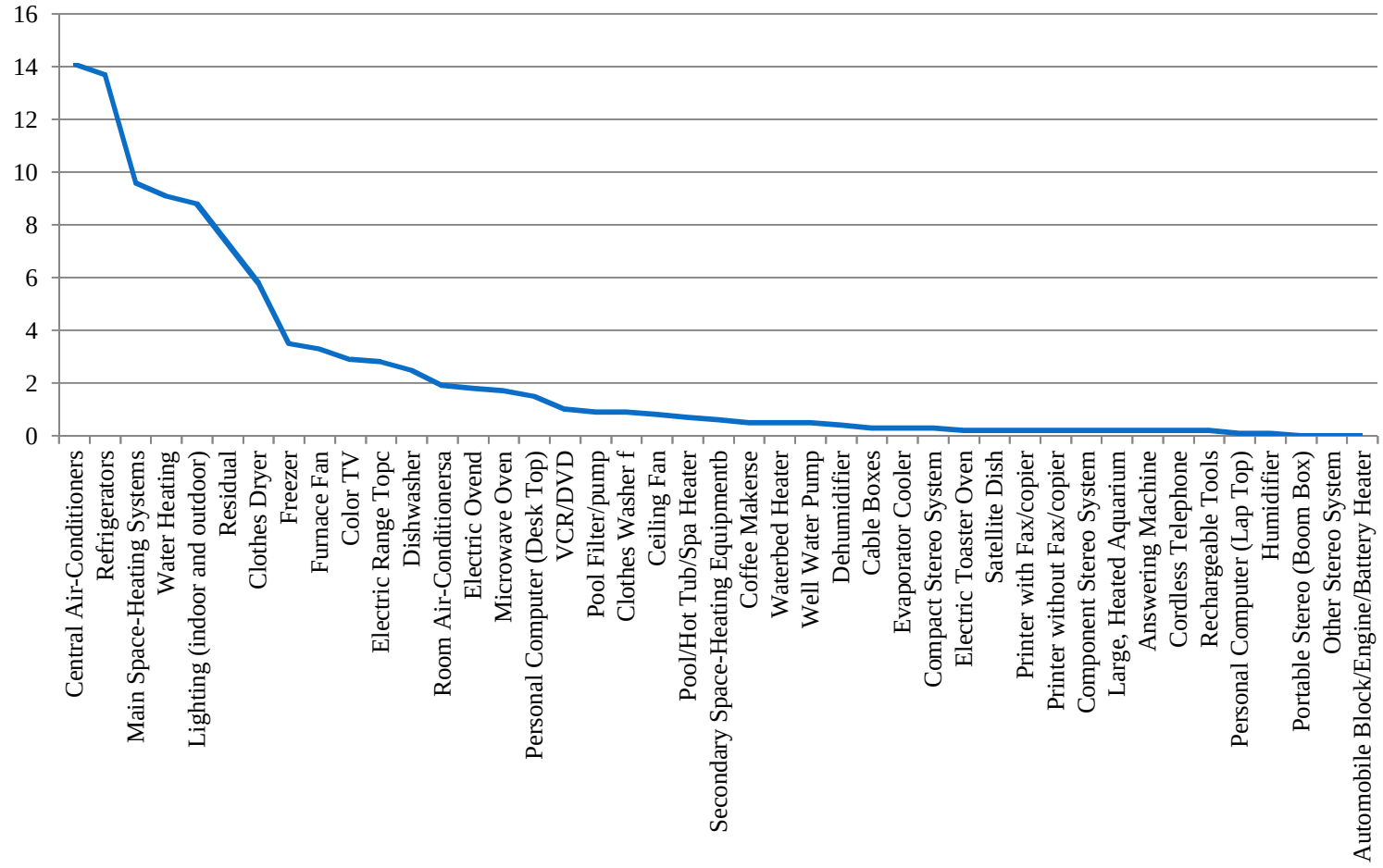
- Goal of the research:
  - Evaluate the impact of community design on energy use.
  - Use findings to improve future community design.

Supplementary data



Supplementary data

Figure 6 End use by share of total electricity use



Source: US DOE EIA *End-Use Consumption of Electricity 2001*,
obtained from *Table 2. Residential Consumption of Electricity by End Use, 2001*.