Leveraging Advances in Population Modeling to Support Energy and Water Nexus Knowledge Discovery

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Background

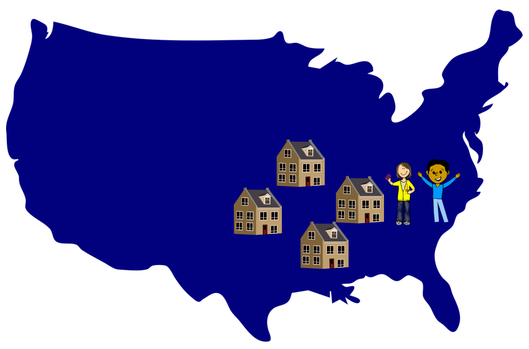
Motivation

- Energy and water generation and delivery systems are inherently interconnected.
- As population and climate scenarios change, new investment decisions will need to be made for optimized energy-water resource management.
- New population-based analytics are needed for understanding, designing, and developing efficient local and regional practices related to the energy-water nexus.




The UrbanPop Population Model

- UrbanPop simulates high-resolution nighttime and daytime locations of all United States (U.S.) households and residents.
- Household/resident locations are simulated at the Census block group-level.
- User can choose population and household characteristics, such as sex and number of bedrooms, to include with each simulated resident/household.

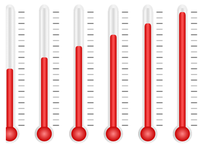


Approach: Using UrbanPop to Model Electricity and Water Consumption

- We propose a framework that combines UrbanPop results with electricity and water data sets to simulate Census block-group level electricity/water estimates.
- Understanding relationships between demographics and resource consumption is useful for predicting current and future consumption patterns under various population and climate change scenarios

We can examine future scenarios such as:

What happens if city x's population and climate change to resemble city y's population and climate?



Methodology

General Framework

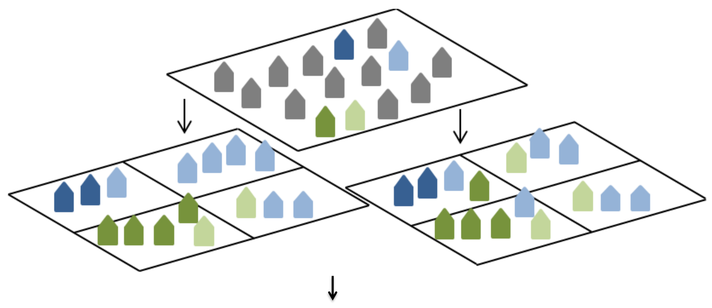
Step 1

Use electricity or water data to learn probability distributions over different types of households.

Household	Household Type	Electricity or Water Demand Distribution
	1 bedroom, attached	
	2 bedroom, detached	
	1 bedroom, detached	
	4 bedroom, attached	

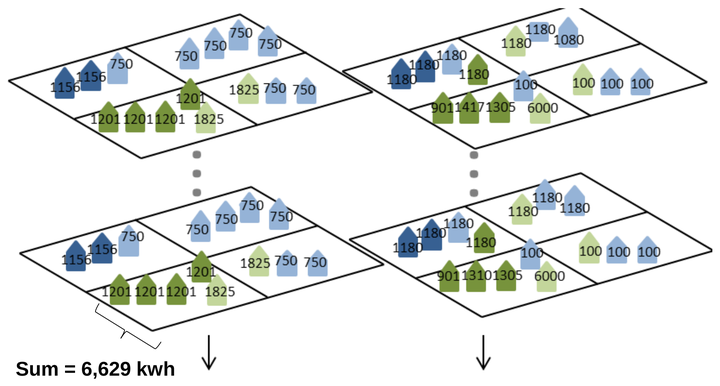
Step 2

Use UrbanPop to simulate several compositions of households in each block group.



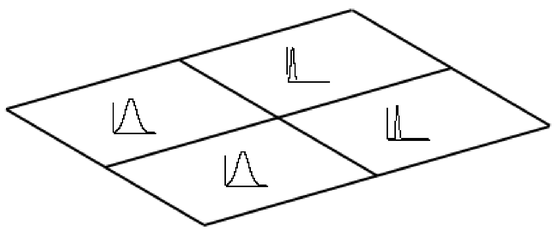
Step 3

For each household use categorical probability distributions to simulate several values per household.



Step 4

Summarize by reporting relevant statistics such as the median and standard deviation for each block group.



Case Study

- We used UrbanPop and Monte Carlo simulation techniques to estimate **the mean and standard deviation of the average aggregate monthly electricity consumption** for all Census **block groups** intersecting the **Knoxville urbanized area** defined by the Census in 2012 (Census 2012).
- We categorized houses by number of bedrooms (between 1 and 4 or more) and whether they were detached or attached.

Step	Data Source
1	Residential Electricity Consumption Survey (RECS) (Energy Information Administration 2009).
2	American Community Survey (ACS) data (US Census 2012).

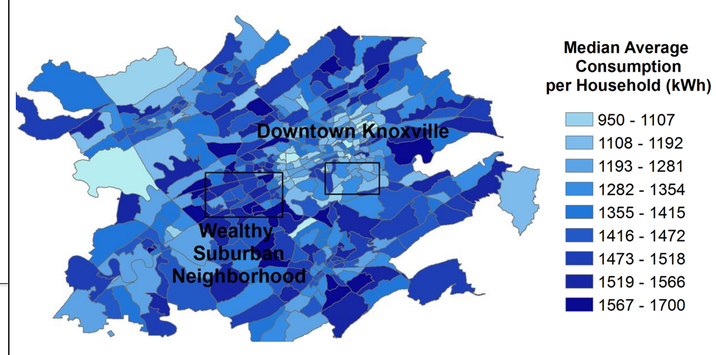
Detached Home

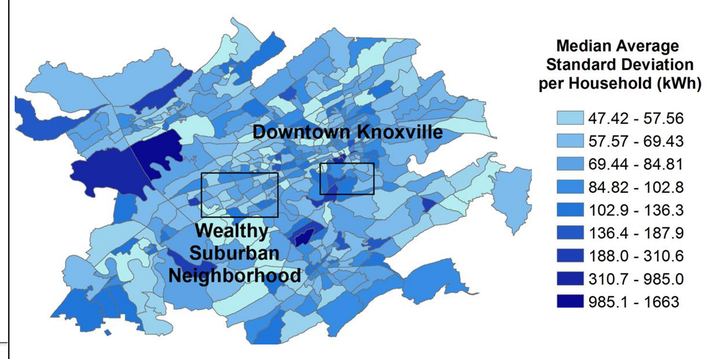
Attached Homes

Results

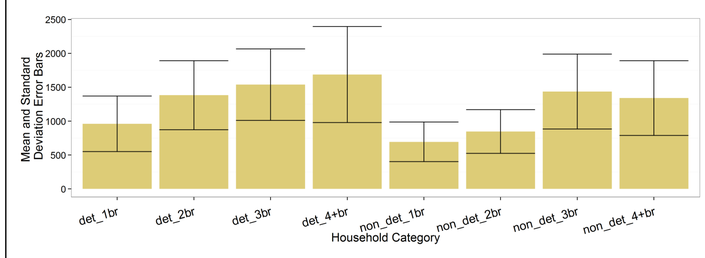
Residential Electricity Results

- Median 2008 – 2012 average consumption and standard deviation per household for block groups intersecting the Knoxville urbanized area.





- Mean monthly electricity consumption and standard deviation error bars (kWh) by household category



Conclusion/Future Work

- We proposed a population-based framework for estimating energy and water consumption to support energy and water nexus knowledge discovery.
- Next steps include simulating electricity and water consumption for other cities and examining future population and climate scenarios.

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