An Analysis of Observed Urban Heat Island in Greenville, NC and Its Implication on Energy Consumption and the Environment

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Introduction:

Urban Heat Island (UHI): Air temperatures in the core of a city are higher than those in surrounding suburban and rural areas. The temperature difference is a measure of UHI strength.

Significance of UHI: energy consumption, air and water quality, public health.

Rationale: Previous studies of UHI have focused on large cities (population more than 100,000). Greenville, NC is a smaller city (population 76,058 in 2007). However, Greenville’s population has steadily grown by 69% over past 18 years.

Objectives:

To quantify the magnitudes and climatology (diurnal and seasonal characteristics) of UHI in Greenville.

To quantify the relations between the strength of UHI and weather conditions (solar radiation, wind speed).

To quantify the relations between energy consumption and weather data.

To develop simple models for the prediction of energy demand for the City of Greenville.

Weather and Electricity Data:

The Department of Geography at East Carolina University developed and maintains two automated weather stations. The BI1 (urban) station is located in the core of the City of Greenville, and the WRC (rural) station is located on the outskirts of the city.

Wind speed and direction, air temperature and relative humidity, barometric pressure and incoming solar radiation are measured every 10s while the precipitation is continuously measured. 5-min averages and totals of these measurements are archived. For this study, hourly averages of the weather data are used to match the hourly electricity data provided by Greenville Utilities.

The time period of these weather and electricity data reported here is from July 17 to October 31, 2008.

Hourly electricity data were recorded at 24 sub-bus stations for various sections in the City of Greenville, and 2 stations in the City of Winterville which is next to Greenville.

http://www.ecu.edu/cs/geo/CURRENTWEATHER.cfm

Results: UHI

Seasonality of the Diurnal Pattern of UHI

- UHI is stronger at night than in the daytime.
- UHI becomes weaker from July to September, but this trend reverses in October.
- UHI increases with decreasing wind speed.
- Maximum UHI strength is as great as earlier observations in many big cities.

Influence of Solar Radiation on UHI

The greater incoming solar radiation in the daytime, the stronger UHI at night.

Combined Effects of Wind Speed and Solar Radiation on UHI

Results: Relation between Electricity Use and Air Temperature

- Air temperature is the predominant factor influencing electricity use.
- Electricity use increases with increasing air temperature nearly in a linear fashion from July to September.
- However, this relation is more complicated (non-linear) in October, which also varies spatially.
- A linear regression is applied to monthly data for July – September.

Results: Electricity Use

Seasonality and Spatial Variability

- Seasonality is illustrated by the differences in the magnitudes, peak hours and number of peaks.
- Spatial variability is shown by the differences among different stations of the monthly averaged diurnal patterns.

Results: Electricity Use

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