Impacts of extreme heat and drought on electricity production and consumption

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Introduction

Both electricity consumers and electricity producers face significant challenges and uncertainties, particularly as a result of impending climate change and the extreme weather events. Understanding the impact of these extreme events on electricity consumption and production is paramount in order to better anticipate possible blackouts and brownouts that can have a significant impact on the economy and human well-being.

Summary of challenges and the research needs associated with them:

Heat & Drought Modeling Challenges

- Unique city-scale heat and drought extremes patterns, different from global or regional patterns, requiring localized fine-grid climate modeling

Electricity Consumption Impact Challenges

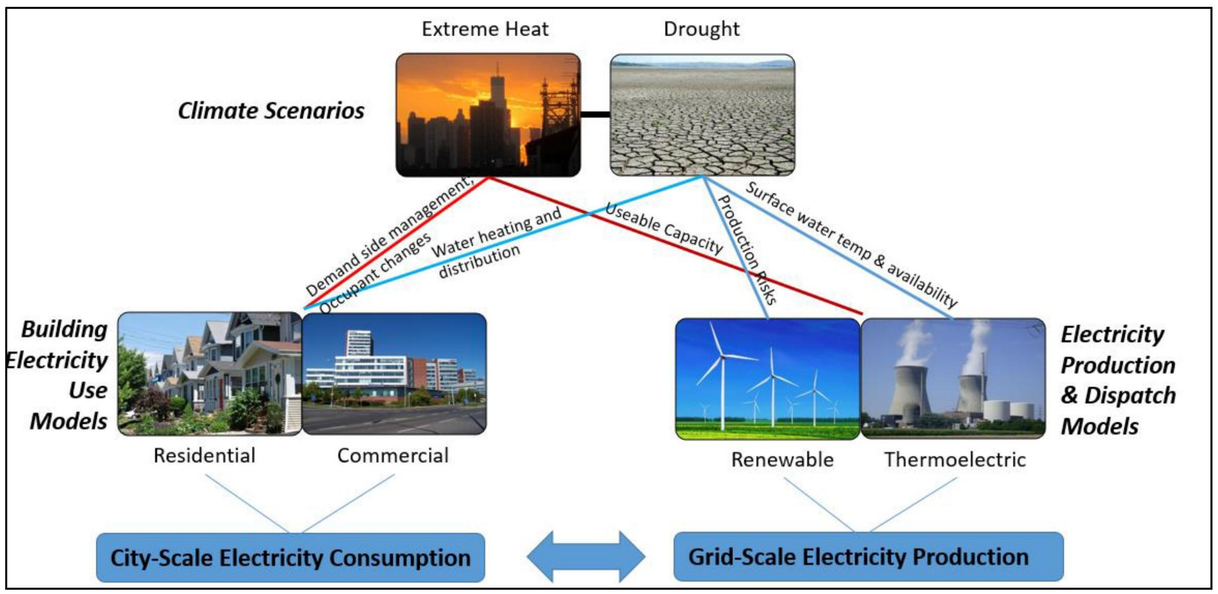
- Building to city-scale electricity consumption prediction method and uncertainty assessment that integrates the use of demand side management

Electricity Production Impact Challenges

- Quantifying grid reliability considering different impacts of extreme heat and drought on each power plant type
- Incorporating climate prediction uncertainties into power generation decision-making

Project Overview

(a) Definition of city-specific future extreme heat and drought scenarios; (b) quantifying the impact of these scenarios on a city's electricity consumption; and (c) quantifying the impact of these scenarios on electricity production servicing the city



Proposed framework for evaluation of and preparation for the impact of extreme heat and drought on city-scale electricity consumption and production.

Prediction of city-specific future extreme heat and drought scenarios:

To predict extreme heat scenarios, significant detail about changes in the frequency of occurrence, magnitude, and diurnal variability of climate-related variables need to be obtained.

- Climate model outputs do not show the impact of localized warm areas due to, say, urban heat islands in densely populated city environments.

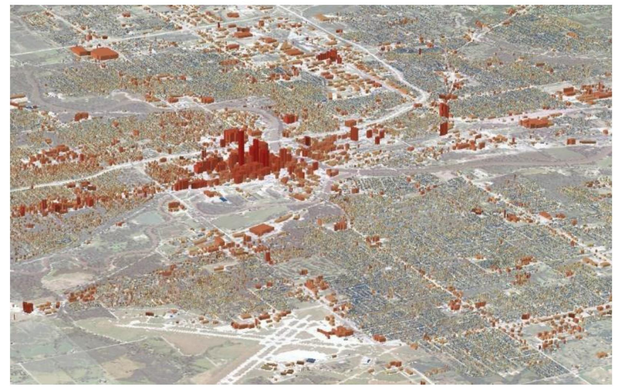
- To predict drought scenarios we need to show a correlation between increased drought events and warmer surface temperatures, suggesting that the current warming of the planet may lead to increasing drought problems in the future.

Quantification of impact of these scenarios on a city's electricity consumption:

The occurrence of extreme climate events significantly impacts a city's electricity consumption, the majority of which is by residential and commercial buildings 75% and 25% Industrial buildings.

- A method that uses scaled-up building energy modeling using a more robust and flexible energy simulation procedure is needed.

- Current city-scale electricity consumption methods also do not take into account DSM techniques that influence how and when buildings use electricity.



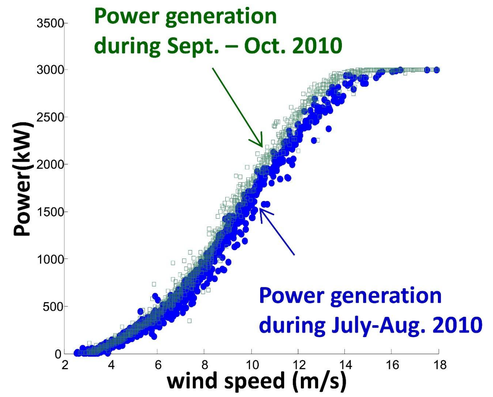
An example of building electricity use in a city block.

Quantification of impact of these scenarios on electricity production servicing the city:

In general, electricity production is less efficient during extreme heat and drought.

- 1°C increase in ambient temperature reduces the power output by 0.45% to 0.8%, depending on the plant type and cooling system type

- Wind and solar power systems show a drop in efficiency during extreme heat, although this drop appears less significant than is the case with thermal power plants.



An scatter plot of power generation vs. wind speed at two different periods from an operating wind farm in Illinois